A

MICROSCOPIC EXAMINATION

OF

THE WATER

SUPPLIED TO THE INHABITANTS OF LONDON

AND THE

SUBURBAN DISTRICTS;

ILLUSTRATED BY COLOURED PLATES, EXHIBITING THE LIVING ANIMAL AND VEGETABLE PRODUCTIONS IN THAMES AND OTHER WATERS,

AS SUPPLIED BY THE SEVERAL COMPANIES;

WITH AN EXAMINATION, MICROSCOPIC AND GENERAL,

OF

THEIR SOURCES OF SUPPLY,

AS WELL AS OF THE HENLEY-ON-THAMES AND WATFORD PLANS, ETC.

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ALSO OF 'A HISTORY OF THE BRITISH FRESH-WATER ALGÆ.'

LONDON:

SAMUEL HIGHLEY, 32, FLEET STREET.

1850.

Mrs Benjamin S. Shaw
June 2. 1893

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TO

THE RIGHT HONORABLE

THE EARL OF CARLISLE.

MY LORD,

To no person could a work relating to an important Hygiènic Question be more appropriately DEDICATED, than to a nobleman distinguished not only for the great interest which he has ever displayed, but also for the active part which he has taken, in all matters relating to the sanitory condition of the people. It was this feeling which led me to address myself to you, and which now prompts this Dedication, as a slight tribute of respect and admiration, and as an evidence of the appreciation entertained of your devotion to the good and great causes of Health and Morality.

In this little work, the subject of Water is considered more particularly in a scientific point of view; facts and observations are dealt with—no particular scheme or plan is advocated; it is therefore in every respect independent, and is published in the warmest hope that it may assist, in some degree, in furthering those objects which you yourself evidently have so much at heart.

I have the honour to remain,

MY LORD,

Your Lordship's very obedient servant,

ARTHUR HILL HASSALL.

Richmond; April, 1850.

A

MICROSCOPIC EXAMINATION OF WATER,

&c. &c.

The attention of the public being at the present time so strongly directed to the acknowledged defective condition of the water supply of London, it is proposed in the following pages so to put together the principal facts connected with a subject of such high importance, as that the actual state of the question, the extent and nature of the evils complained of, and the remedies for some of them, may be clearly understood by all.

It long since occurred to me that the microscope (with the powers of which beautiful instrument most persons are now more or less acquainted) might be usefully applied to the investigation of the condition of water; in this expectation I have not been disappointed, and facts of great interest have thus been brought to light, the more important of which I shall proceed to place before the reader. It is not intended, however, in this little work, to speak only of microscopical details, but to take a more general and enlarged view of the whole subject.

In the chemical analyses of water generally given, we find, under the heading "Organic Matter," the word "*traces*;" and this, in the majority of instances, is the only information we obtain from the chemist, in reference to the most important contamination to which water is liable. Of these "traces" we shall now treat more particularly, and show of what they consist, in the waters in general use, and especially in those supplied to the inhabitants of this metropolis by the several water-companies. In the course of this investigation,

it will become apparent that these traces are not inconsiderable in amount, that they are complex in organization, endowed with life, and in many cases possessed of active powers of locomotion.

As, amongst other terms, the words *Infusoria*, *Entomostraceæ*, *Conferveæ*, *Desmideæ*, and *Diatomaceæ*, will have to be occasionally employed, it may be proper, at the outset, to define, simply and briefly, the meaning of these appellations.

The *Infusoria* are animal productions, and include a great variety of singularly organized atoms, most of which are invisible to the common eye, and are known by the popular name of Animalcules.

The *Entomostraceæ* constitute a well-defined division of the *Crustaceæ*, or the Crab tribe, and are remarkable for having their bodies enclosed in shell-like cases; it contains the genus *Cyclops*, as well as certain other genera and species, which have been called *Monoculi*, from the singular fact, that they are all provided with but a single eye, which is placed in the centre of the head. These animals abound in many waters, and are to be found at all seasons of the year.

The *Conferveæ* are vegetable productions of very simple organization, consisting of cells or utricles, placed end to end, and joined together, forming, by their union, threads, often of extreme fineness, which are either simple and undivided, or branched.

The *Desmideæ* are also vegetable productions, exhibiting, however, some affinities to animals, so that, for a long time, it was a matter of doubt and dispute to which of the kingdoms of the organic world they really belonged. Recent investigations have, however, determined their vegetable nature. They also consist of cells; but these are rarely united so as to form threads or branching figures, but are joined together in twos, a number of very elegant shapes resulting from various modifications in the size and structure of the component cells.

The *Diatomaceæ* unite in their organization the characters of both plants and animals, insomuch that it is still uncertain which they really are. They are readily distinguished from all other organisms by their colour, which is brown,

and by the fact that they are furnished with skeletons of Silex, or flint; it is this which renders them so durable—indeed, almost indestructible.

The three divisions *Conferveæ, Desmideæ*, and *Diatomaceæ* are now all included under the general designation *Algæ*, although formerly the two latter were regarded as *Infusoria*, and are described as such in Baron Ehrenberg's great work, a monument of patient and acute observation.

In addition to the numerous species of living productions appertaining to the classes just defined, there are encountered in many waters the sporules and branched threads of *Fungi*.

The *Infusoria* and *Entomostraceæ* are most abundant in the spring, summer, and autumn months, but several species live through the winter in great numbers.

The *Algæ* are amongst the first of organized productions to be called into life and activity on the approach of warm and genial weather; and in all stagnant and impure waters they are to be found in great quantities, during the spring, summer, and autumn; in the winter, the *Conferveæ* and *Desmideæ* disappear for the most part, although some few species contrive to linger through even the most inclement weather: the siliceous *Diatomaceæ* generally survive the winter, and may be met with in abundance at any, even the severest, period of the year.

The *Fungi* may also be detected at nearly all times of the year, but the summer and autumn are their proper seasons.

Lastly, there is contained in most waters, in greater or less quantities, according as it is more or less pure, dead and decaying animal and vegetable matter, partly in the solid form, and partly in solution, as well as certain gases.

The above short and introductory remarks, it is hoped, will render what follows clear and intelligible. We now proceed to the examination of the several waters.

In the first instance, it will be proper to give the microscopic examination of Thames water itself, as it is this which is supplied to the greater part of the inhabitants of London; in the next, that of the water of each Metropolitan Company, as it is furnished to the public; and, lastly, the analysis of the water of cisterns.

EXAMINATION OF THAMES WATER.

It occurred to me that it would be desirable to give two microscopic analyses of this water,—the one of a sample obtained from near Brentford, this being the highest point of the river from which, at present, any company derives its supply; and the second procured from off Lambeth, from which locality, also, one of our companies takes its water.

Examination of Water from Brentford.

A wine-bottleful of this water, examined by the microscope, was found to contain—

1st. Animal and vegetable matter in a state of decomposition, in considerable quantities.

2d. Two or three species of worm-like animals, or *Annelidæ.*

3d. Living *Entomostraceæ.*

4th. Several species of *Infusoria.*

5th. Numerous filaments of *Conferveæ.*

6th. Living species of *Desmideæ.*

7th. Several *Diatomaceæ.*

8th. *Fungi.*

9th. Earthy matter.

On allowing the heavier particles contained in a test-tube filled with this water to subside, and examining a drop of the sediment, it was found to present the appearance represented in Plate I, fig. 1.

Examination of Water from Lambeth.

The same quantity of this water, collected two hours after the steam-boats had ceased to ply, presented an opaque and dirty appearance, and was found to contain—

1st. *Infusoria* in great numbers, *Paramecia, Oxytricæ, Uvellæ,* &c. &c.

2d. *Diatomaceæ,* very few; *Actinocyclus Octonarius, Gyrosigma Hippocampa.*

3d. Filaments of *Fungi; Torulæ, Sporangia.*

4th. Dead organic matter, very considerable, both animal and vegetable; ochreous substance; down of wheat.

It is to be observed that this water differs principally from that procured at Brentford, in the much greater numbers of animalcules contained in it, and in its comparative freedom from vegetable productions. (See Plate I, fig. 2.)

A second examination of Thames water from Lambeth, made more recently, gave the following results. The water, when first taken from the river, was thick and muddy, evidently containing much earthy matter in suspension; after having been allowed to remain undisturbed for twenty-four hours, it still appeared thick and opaline, and of a dirty straw colour, the opacity being so great that the form of the hand placed behind a clear glass bottle full of the water could not be discerned. A few drops examined with the microscope displayed the presence of minute *Infusoria, Vibriones,* filaments of *Fungi,* globular colourless bodies resembling ova, and granular and grumous masses, consisting of both dead and living organic matter: it was to the presence of all these that the water owed its colour and opacity. Put aside for a few days, *Infusoria* of large size speedily made their appearance, and the water evolved an odour in a high degree offensive. The solid residue, which, after the water had been standing for some time, fell to the bottom, was found to consist in great part of dead vegetable and animal matter, and it was this, still more than the earthy particles, which troubled the water, and occasioned its turbidity. When Thames water is at rest, the grit falls to the bottom in a few minutes, but still in most cases the water does not recover its transparency; this is owing to the suspension in it of minute organic fragments, which being less heavy, take a longer time to subside.

The differences in the results of these examinations of Thames water, the predominance of vegetation in the water from Brentford, and of animal life in that procured at Lambeth, struck me as so remarkable, that I was induced to make a series of observations on the river water, both upwards and downwards, in the course of the river from London. These have brought to light the singular and important fact, that Thames water, from Brentford in one direction, to Woolwich in an opposite, swarms with living

productions, principally of the genus *Paramecium,* and of one species of this genus, the *P. chrysalis* of Ehrenberg. These animalcules exist in such vast numbers, that a wine-bottle of the water obtained in any condition of the river, at high or at low tide, is sure to contain large quantities of them. They are met with in the greatest abundance near to London, and in the neighbourhood of the bridges. At Barnes they may be detected at all times, although in diminished numbers, while at Kew they have in general almost disappeared: going in an opposite direction, we meet with them in abundance at Blackwall, and more sparingly even at Woolwich. It is most probable that at high and spring tides these limits are much exceeded, especially down the river, for it is to be supposed that these creatures are ultimately, together with a variety of other matters, discharged into the sea.

We shall come presently to the explanation of the remarkable differences just pointed out, and to the reason why Thames water should thus teem with life.

Thames water, then, within the limits of the examinations above given, contains a large amount of organic matter, either living or in the state of decomposition and solution.

But the organic matter and other impurities of Thames water exist in more than microscopic quantities.

Let the observer walk along the banks of the river for a short distance, and the following will, in most cases, be the result of his observations:

In one spot he will notice the carcases of dead animals, rotting, festering, swarming with flies and maggots, and from which a pestilential odour proceeds, contaminating the air around; in another, he will see a variety of refuse borne along by the lazy current of the stream—decaying vegetables, the leaves and stalks of cabbages, grass from a recently-mown lawn, excrement; in another, he will remark the commotion of the water, occasioned by the bubbling up of some noxious gas; and still further on, he will perceive some sewer, discharging its corrupt and filthy contents (consisting of the mingled refuse of, perhaps, a whole town or district) into the bed of the river, causing the water around to assume an

inky blackness. Should the tide happen to be out, the observer should now abandon the towing-path, take a boat, and row to some of the shallower parts of the stream. If here he plunges his hand into the water, he will bring up a dirty and slimy mass; this, examined microscopically, will be found to consist of *dead* organic matter, together with vast numbers of *living* animal and vegetable productions. Entire acres (I might say without exaggeration) of a substance similar to the above may frequently be noticed on the recession of the tide.

Sewer Water.

The Thames being the receptacle of the sewage of London, and of the many populous towns on its banks and numerous tributary streams; and as this sewage is daily poured into the bed of the river, mingling with its waters, and rendering them turbid and offensive, it becomes interesting to subject it to the same microscopic scrutiny as the Thames water itself has already been made to undergo.

The microscope detects in most sewer waters—

1st. Numerous *Annelidæ*, or worms.

2d. But few *Infusoria*, *Monades* and *Oxytricæ*.

3d. Much dead and decomposing solid organic matter, animal and vegetable; the same in a state of solution; sulphuretted hydrogen, &c.; the cells of the potato, fragments of the husks and hairs of the down of wheat, starch granules, spiral vessels of plants, &c.

4th. A black carbonaceous matter, on which the inky colour of many sewer waters depends.

5th. Portions of an ochreous substance, often striated, and bearing much resemblance to muscular fibre. See Plate II, fig. 1.

Some of the more remarkable characters of sewer water, then, are the presence of sulphuretted hydrogen in large quantity, the comparative absence of infusorial life, the abundance of dead and decomposing organic matter, and the carbonaceous and ochreous substances contained in it.

The large quantity of sulphuretted hydrogen in sewer water, and its injurious and even fatal effects on animal life, will be shown hereafter by experiment.

The abundance of organic matter is made known by the presence of the more indestructible parts of the animal and vegetable tissues, revealed by means of the microscope, as well as by the action of iodine, which turns the starch of the vegetable tissues of a deep blue colour.

Considerable interest is attached to the carbonaceous substance, present in large quantities, in the worst descriptions of sewer water; and it seems probable that it is really to be regarded as a natural carbon, liberated from the organic tissues, especially vegetable, by certain complicated chemical changes. A similar matter is in general to be found at the bottom of old and stagnant ponds, and other collections of water.

Still greater interest, however, belongs to the ochreous substance so largely contained in all sewer water; its frequent resemblance to muscular fibre has already been noticed, and struck me as so remarkable, as to lead to the suspicion of its organic nature. The little effect produced by the application of reagents confirmed me in this idea, and the absence of charring by concentrated sulphuric acid showed me that it was most probably an animal substance. It then occurred to me to make a microscopic examination of some human excrement, and in this I immediately detected the matter in question in great abundance, and in a more perfect condition than in sewer water. It now became evident that the ochreous substance of sewer water is really muscular fibre, broken into short fragments, altered by digestion, and highly tinged with the biliary fluid; that the colouring matter is bile is shown by the use of nitric acid, which causes the ochreous matter to give out the pink tint characteristic of the biliary secretion.

I also noticed in the excrement the cells of the potato, and fragments of the husks and hairs of the down of wheat.

Now, I have observed in Thames water about the bridges, over and over again, the same matters, animal and vegetable, detected in the excrement; it therefore remains to inquire, whence do they proceed, and in what way do they reach the Thames?

It first occurred to me that some of these matters at least were derived from the refuse of the kitchen, but this in general finds its way into the dust-bin, and not into the

sewer; neither could it be supposed that the muscular fibre came from the kitchen. It is beyond question, therefore, that these organic products proceed from the fæcal matter contained in the sewers; and it is evident, consequently, that *Thames water is demonstrably contaminated with human excrement;* there is also little doubt, as will immediately appear, but that it contains, in an undecomposed form, some of the effete animal substances of the urine.

Having completed the microscopic examination of sewer water, I next examined it chemically, and succeeded in detecting in it the colouring matter of the urine, of the bile, some evidences of the presence of urea, but the chlorides, sulphates, phosphates, and carbonates, especially of ammonia, in abundance. Many of these salts, doubtless, have their origin in the urine, the carbonate of ammonia being most probably the result of the decomposition of the urea of the urine. Drops of sewer water, evaporated on slips of glass, presented many of the crystalline forms often observed in the renal secretion, treated in a similar manner.

EXAMINATION OF THE WATERS SUPPLIED BY THE SEVERAL METROPOLITAN WATER-COMPANIES.

Grand Junction Company.

Before entering further into this analysis, it may be right to state that the quantity of water submitted to examination was in all cases the same, namely, a wine-bottleful.

This water contained—

1st. Living *Annelidæ*, a few.

2d. *Desmideæ; Closterium Ehrenbergii, Scenedesmus quadricaudatus.*

3d. Living *Infusoria. Monades, Paramecium chrysalis*, small; *Oxytricha gibba? O. cicada*, both not uncommon; *Euglena viridis, Amphileptus Margaritifer.*

4th. Filaments of *Confervæ. Mougeotia.*

5th. Several species of *Diatomaceæ*—viz., *Gomphonema cristatum, Fragilaria pectinalis, Gomphonema capitatum, Encyonema prostratum, Asterionella formosa, Meloseira varians, Exilaria Ulna, Gyrosigma Hippocampa.*

6th. Filaments of *Fungi, Torulæ.*

7th. Hairs of a Mammalian animal.

8th. Dead organic matter, spiral vessel of plant.

9th. Earthy matter, or grit.

The stelliform *Diatoma,* to which I have given the name *Asterionella formosa,* is very abundant in this water, and its presence constitutes one of its most remarkable features.

The drawing (Plate II, fig. 2) represents the more characteristic of the living organisms contained in it.

The Grand Junction Company takes its supply from the Thames at Brentford, and within reach of the sewage of that large and dirty town.

West Middlesex Company.

The microscope revealed in this water—

1st. Living *Entomostraceæ; Cyclops quadricornis, Lynceus longirostris.*

2d. Several species of *Infusoria; Uvella virescens, Paramecium chrysalis,* numerous; *Cryptomonas curvata, Peridinium furca?*

3d. *Diatomaceæ; Exilaria Ulna, Meloseira arenosa, Navicula bifrons, Gomphonema capitatum, Cocconema cymbiforme, Gomphonema minutissimum, Asterionella formosa,* a few.

4th. Filaments of *Fungi; Torulæ.*

5th. Filaments of *Confervæ,* sporules of same; *Vaucheria.*

6th. Dead organic matter.

7th. Earthy matter, considerable.

No organic production was met with in this water absolutely characteristic of it, although it was observed to contain animalcules, of the genus *Paramecium,* in great numbers; some of these, together with other forms, are delineated in Plate III, fig. 1.

The West Middlesex Company obtains its water from Barnes, opposite Hammersmith.

Chelsea Water Company.

There were present in this water:

1st. *Entomostraceæ, Cyclops rubens,* a few, ova of same, a species of *Nauplius.*

2d. *Infusoria,* rather numerous, *Monades, Paramecium chrysalis, Oxytricha cicada, Actinophrys difformis, Rotifer vulgaris, Stentor polymorphus, Paramecium caudatum, Uvella virescens ;* ova cases of some animalcule in bunches, abundant.

3d. Sporules of *Algæ.*

4th. Filaments of *Fungi.*

5th. *Diatomaceæ,* a few; *Meloseira varians, Exilaria fasciculata.*

6th. Decaying vegetable matter, fragments of straw.

7th. Earthy matter.

The most evident feature of this water was the presence, in great numbers, of the ova cases above referred to; in other respects, the organic matter contained in it was less than in the two previous analyses. The ova cases are figured in Plate IV, fig. 1.

The Chelsea Company takes its supply from the river, near Battersea.

Southwark Company.

This Company is now united with the Vauxhall Company; nevertheless, as it was, I believe, once distinct, as it has separate works, and, more particularly, as the water of each differs in the character of its living contents, it will be proper to give the results of each examination separately, and first those of the examination of the water of the Southwark Company.

1st. *Annelidæ,* a few.

2d. *Infusoria,* in immense numbers; *Paramecium chrysalis, P. caudatum, Oxytricha gibba* (?) *; Actinophrys difformis, Rotifer vulgaris, Uvellæ,* &c.

3d. *Diatomaceæ,* very few; *Gyrosigma Hippocampa.*

4th. Filaments of *Fungi ; Torulæ.*

5th. Dead organic matter, considerable; cells of potato, ochreous substance.

6th. Hairs of *Mammalia* numerous. See Plate IV, fig. 2.

This water was in the worst condition in which it is possible to conceive any water to be, as regards its animalcular contents, in a worse state even than Thames water itself, as taken from the bed of the river. The *Infusoria* abounded in it, especially the spiny *Actinophrys difformis.*

A curious fact in connexion with the water of the Southwark Company has been mentioned to me by Mr. Hett, surgeon, of Bridge street (the successful injector of anatomical preparations for the microscope)—viz. that a gauze bag, tied to the tap of the water cistern, is found, at the end of a few days, to contain a mass sufficient to fill an eggshell, consisting principally of the hairs of Mammalian animals.

This Company takes its supply from the Thames, near to Vauxhall, in common with the Vauxhall Company.

Vauxhall Company.

The sample of the water of this Company submitted to examination contained—

1st. *Annelidæ,* very large and numerous.

2d. *Infusoria,* in great numbers; *Vorticella nebulifera,* abundant; *Paramecium chrysalis, Actinophrys difformis, Uvellæ, monades, Oxytricha gibba, O. cicada.*

3d. *Diatomaceæ,* a few; *Meloseira varians, Navicula amphisbœna, Exilaria Ulna.*

4th. Organic bodies, nature undetermined.

5th. Dead organic matter; grit; exuvial masses; hairs of down of wheat; ochreous matter, most probably muscular fibre tinged with bile.

This water contained the *Paramecium chrysalis* in great numbers, and a few of the *Actinophrydes;* but its chief peculiarity was a species of Annelid, or worm, of which I observed a great many in two separate quantities of water. Taken altogether, this water was the most disgusting which I have ever examined: when I first saw the water of the Southwark Company, I thought it as bad as it could be, but this far exceeded it in the peculiarly repulsive character of living contents.

Lambeth Company.

The analysis of the water supplied by this Company is as follows:—

1st. *Infusoria* of the genera *Monas, Oxytricha,* and *Paramecium; O. gibba, P. chrysalis,* the last in immense numbers.

2d. *Desmideæ*, a few; *Scenedesmus quadricaudatus, Pediastrum tricyclium.*

3d. *Diatomaceæ*, a few; *Gyrosigma Hippocampa, Exilaria Ulna, Nitzschia elongata, Cocconeis, Pediculus.*

4th. Filaments of *Fungi.*

5th. Dead organic matter; husks and hairs of down of wheat.

6th. Hairs of *Mammalia.* (See Plate V, fig. 1.)

This water, like the two preceding, swarmed with living animalcules, especially the Thames one—the *Paramecium chrysalis.*

The water used by the Lambeth Company is procured from the river at Lambeth, and not far from a large sewer.

It will be observed that the water of the Companies on the Surrey side of London, viz. the Southwark, Vauxhall, and Lambeth, is by far the worst of all those who take their supply from the Thames; they all contain animalcules in vast numbers, and, for the most part, of the same species; thus we notice in them all the *Paramecium chrysalis* and *Actinophrys difformis;* the former unquestionably has its origin in the Thames, it being the species which so abounds in Thames water. They are also demonstrably contaminated with more or less of the organic and decomposing matters, animal and vegetable, derived from sewer-water.

Having now given the analyses of the water of those companies which take their supply from the Thames, we, in the next place, proceed to speak of those which have a different source, as the New River, Hampstead, East London, and Kent Companies.

New River Company.

This water was found to contain:

1st. *Entomostraceæ; Lynceus longirostris, Cyclops quadricornis.*

2d. *Infusoria*, not numerous; *Cryptomonas curvata, Bursaria Pupa, Vorticella nebulifera,* ova cases, a few.

3d. Filaments of *Vesiculifera, Oscillatoria,* two species.

4th. *Desmideæ; Scenedesmus quadricaudatus.*

5th. *Diatomaceæ; Gyrosigma Hippocampa, Nitzschia elongata, Fragilaria rhabdosoma, Cocconema lanceolatum, Sphinctocystis librilis, Navicula nodosa, Gomphonema capitatum, Exilaria Ulna, Navicula undulata, Surirella striatula.*

6th. Filaments of *Fungi*, abundant.

7th. Dead organic matter, plentiful.

8th. Much earthy matter.

Of the above water it is to be remarked, that the living animalcules were not very numerous, but that it contained great numbers of *Diatomaceæ* of several species and genera. The more obvious forms are shown in Plate V, fig. 2.

Hampstead Water Company.

The contents of this water were:

1st. *Entomostraceæ*, numerous; *Daphnia quadrangula, Lynceus longirostris, L. trigonellus, L. sphæricus, Cyclops quadricornis*, ova of same.

2d. *Infusoria, Aneurea foliacea, Aneurea testudo, Peridinium acuminatum, Coleps hirtus, Monads*, &c.

3d. *Diatomaceæ*, a few, *Navicula platystoma, Nitzschia elongata, Exilaria Ulna.*

4th. Filaments of *Fungi.*

5th. Dead organic matter.

6th. Scales of a moth. See Plate VI, fig. 2.

This water is generally bright and clear, depositing little sediment; it is distinguished from the water of all other Companies by the number of *Entomostraceæ* and of certain species of *Infusoria* contained in it; the presence of these is explained by the nature of the source from which the water is procured, and of which more will be said hereafter.

East London Company.

There were visible in the water of this Company:

1st. *Entomostraceæ*, a few; *Daphnia quadrangula*, shells of dead *Nauplius* abundant.

2d. *Infusoria*, a few; of the genera *Monas*, *Cryptomonas, Bursaria, Oxytrica, Uvella, Euglena, E. longicauda.*

3d. *Conferveæ*; Filaments of *Cladophora glomerata, Vesiculifera,* and *Vaucheria,* living sporules of *Algæ.*

4th. *Diatomaceæ,* very numerous; *Surirella striatula, Gomphonema cristatum, G. truncatum, Gyrosigma Hippocampa, Nitzschia elongata, Navicula platystoma, N. bifrons, Diatoma elongatum,* as well as some undescribed forms.

5th. Filaments of *Fungi; Torulæ; Sporules.*

6th. Dead organic matter, *Fat-like* granules.

This water resembles very closely in its organic contents that of the New River Company, the reason of which will presently appear. See Plate VI, fig. 1.

Kent Company.

This water was found to contain:

1st. *Annelidæ,* one or two.

2d. *Infusoria,* rather numerous; a species of *Trachelius,* common; *Trachelocerca viridis, Oxytricha caudata, O. Gibba, Vorticella nebulifera, Microglena monadina.*

3d. *Entomostraceæ,* shells of.

4th. *Diatomaceæ,* abundant; *Navicula gibba,* common; *N. platystoma, Sphinctocystis librilis, Meloseira varians, Surirella striatula, Frustulia viridis,* common.

5th. Dead organic matter, grit.

Before proceeding with the examination of the water of cisterns, it remains to observe, that the samples examined above were procured, in one or two instances, from reservoirs, but in general from the service pipes of the several companies; the water thus obtained, was in the exact condition in which it was supplied for public use.

The water procured from different service pipes supplied by the same company and from the same pipes at different periods is found to vary considerably; this is probably due to many causes, as the position of these pipes, the condition of the mains, and the state of the weather, the water after much rain containing, in general, considerable sediment.

The accumulation of solid matter in the main supply pipes is often so great as to require that these should be frequently cleansed out; this circumstance, and the variation

of the amount of earthy matter in accordance with the weather, show clearly the defective state of the processes of filtration adopted. Lastly, if solid earthy and inorganic matters are largely contained in the waters of the companies, as supplied to the houses, it is evident that no reason can exist why the *organic* and *living* matters characteristic of impure water should not be present in them to any equally large extent.

Examination of the Waters of Cisterns.

It may be observed, in general, that these waters contain the same forms of organic life as those encountered in the waters of the several companies, with this important difference, however, that their numbers, for equal quantities of fluid, are usually much greater in the former than in the latter case.

This identity gives to certain cistern-waters the same peculiarities which belong to the waters of the companies.

Thus, the water taken from the cisterns supplied by the "Grand Junction Company" is usually found to contain large numbers of the *Stellate Diatoma, Asterionella formosa.*

That of the "West Middlesex Company" has a less decided character, but numerous *Infusoria* of the genus *Paramecium,* may generally be detected in it.

That of the "Chelsea Company" is remarkable for its bunches of *Ova* cases.

That of the "Lambeth Company," for its immense numbers of *Bursariæ* and *Paramecia.*

That of the "Southwark Company," for its multitudes of *Actinophryides, Oxytrichæ, Paramecia, Rotifera,* &c.

That of the "Vauxhall Company," for its hirsute worms or *Annelidæ.*

That of the "New River," for its various species of *Diatomaceæ.*

That of the "Hampstead Company," for its *Entomostraceæ,* especially *Daphnia quadrangula.*

That of the "East London Company," for its *Entomostraceæ* and *Diatomaceæ.*

That of the "Kent Company," for the numerous

Trachelii and *Amphilepti,* as well as for the abundance of the *Diatoma, Frustutia viridis.*

Varieties in the nature of the living contents of our cistern waters depend upon the different periods of the year; the above remarks apply in general to their condition in the early part of the month of November of the last year.

The increase in the quantity of living organisms, above referred to, is particularly evident in respect to those curiously formed creatures, the *Entomostraceæ;* these consist of numerous genera, and are the largest animals found in our cistern waters, being readily seen with the unassisted eye; they exist at all periods of the year, and are almost always present in cisterns, often in great numbers; they are most readily detected by placing a tumbler filled with the water suspected to contain them between the eye and the light. See Plate III, fig. 2, which is a representation of some of the animals contained in a cistern supplied by the Hampstead Company.

The organic contents of a given quantity of cistern water vary much, not merely with the period of the year, but also with the condition of the cistern itself, as respects cleanliness and the frequency and time of the day at which its supply is renewed.

Thus, should the cistern be in a foul state, or the water only just entered, and then examined, it will be more or less turbid, and will deposit an evident sediment. It will therefore be necessary, before making any microscopic examination of the water, to ascertain the condition of the cistern, and when the water last came in.

Amongst other living organisms present in cisterns supplied with water from the Thames, the *Hydra fusca,* as well as a worm or Annelid of a blood-red colour, are frequently met with : the origin of the last from the river is undoubted. The mud exposed at low water often appears stained in patches of a deep crimson colour, as if blood had been spilled upon it here and there. If one of these patches be touched with the hand or a stick, the colour instantly vanishes, to the astonishment of the observer unacquainted with the phenomenon and its cause, and it is only on a very

close examination that he perceives that it is occasioned by the aggregation in great numbers of the small blood-red worm above referred to.

The same worm occurs in ponds and other stagnant water.

Having now brought the several examinations to a conclusion, it is right to state—1st. That the above analytical results have been confirmed in their principal details by repeated observations. 2d. That the observations upon which these results are founded, were made principally during the months of November, December, January, and February, and therefore at a period of the year when the lower forms of organic life are in their least active condition, when decomposition proceeds most slowly, and when, as a consequence, the waters furnished by the metropolitan companies are in the purest state of which, under the present system of management, they are capable. 3d. That the whole of the organic productions exhibited in the drawings, and which are faithful and unexaggerated representations, were found in a living state within the last two or three weeks.

The area of each figure represents scarcely half the size of the field of the microscope, and contains as many objects only as that space would accommodate without confusion; the dead organic and earthy matters, which tended to obscure vision, being in general omitted, as their frequent representation would serve no useful purpose.

Each drawing, moreover, represents only a very small proportion of the ordinary contents of a wine-bottle of water.

Lastly, it may be remarked that even the lowest powers of the microscope will take into view at one time, only a small portion of a single drop of water, so that the whole of the contents of each illustration were included in a fractional part of one drop of liquid.

In the next place, it becomes necessary to offer a few observations in explanation of the reasons why the waters supplied by the other metropolitan companies is less pure than, on first consideration, might have been anticipated,

when it is remembered that their supply is derived, not from the Thames, but other sources.

A certain amount of the impurities contained in the waters of these companies is also attributable to the practice of confining them in reservoirs; but there are likewise other causes which operate in occasioning their deterioration.

New River Company.

This company derives its supply in part from springs at Amwell and Chadwell, near to Ware in Hertfordshire, the principal Chadwell spring forming the "New River Head;" in part from the river Lea, as well as from wells at Cheshunt and Tottenham; it has also, let it be particularly observed, a communication with that prolific source of London water supply, the Thames, at Broken Wharf, Upper Thames-street.

The "New River Head" is a pool of water of some six yards in diameter; entering it on one side is a small ditch-like stream, which carries water sufficient into the head to keep a twelve-inch pipe supplied; while on the opposite side the water flows slowly away in a small stream of a few feet in width; this, after a short and independent course of a hundred yards or so, unites with another stream broader and apparently still more considerable than itself, which is supplied from the river Lea; the conjoined streams then pass on towards Ware.

The "head" of the New River, therefore, is evidently much indebted to the other members of the body corporate; the independence of the river itself soon ceases, and its water quickly loses its character of spring water by a very copious admixture with river water not of the purest quality,—so much for New River spring-water at Ware in Hertfordshire. We shall see whether its character improves as it gets further on its journey to London.

The condition of the water in the little stream or ditch which assists in supplying the head is very bad, it containing *Infusoria* and *Algæ* in great numbers; this is owing to the unclean and weedy state of the ditch in question.

The condition of the water in the head itself, inasmuch as it receives all the water from the feeding ditch, cannot be

very satisfactory, but the margins of the head are also covered with *Algæ* rising up into the water like clouds, and affording a nidus for the shelter, growth, and development, of *Entomostraceæ, Infusoria,* &c.

The canal itself near to Ware is at the present time in a much better state than I have ever seen it before.

The next accession of strength which the New River receives is at Cheshunt; here the company has a well worked by a steam engine, and two reservoirs; the one of these reservoirs at least contains something more than pump water, it being fed by a small stream nearly dry in summer, but which in rainy weather contributes as well as the pump a fair supply of water.

These reservoirs have very recently been cleaned out, and certainly the operation was much wanted, as I was given to understand that it had not been once performed before, since the reservoirs were made, nearly twelve years since.

Well the cleaning out of these reservoirs occupied nine weeks, and employed thirty horses and not a few labourers; the matter removed consisting of a black muddy substance of an offensive smell, and similar in nature to that contained at the bottom of old ponds, and also to that which has been recently taken out of the Serpentine. This black mud I regard as a sure indication of the presence of organic matter, of which fact those who removed it from the reservoirs seem fully aware, as it has been spread over an adjacent field, to the fertility of which it will doubtless much contribute.

Some years since, the Cheshunt reservoirs were a favorite resort of mine, and on turning to my 'History of the British Freshwater Algæ' I find them given as the habitats of several species; their condition at that period cannot have been very good therefore.

Of the reservoirs at Tottenham I have no knowledge.

It is stated that the communication with the Thames at Broken Wharf is not now made use of; it is to be hoped not; the matter is, however, one of great importance, and ought to be well sifted, and the point definitively ascertained. At all events it is tolerably clear that the New River Company did formerly supply Thames water to the public of the

worst description, and if this be no longer necessary and be really discontinued, I would suggest that the confidence of the public would be best secured by the removal of the works situated in the not very clean locality of Upper Thames-street.

New River water, therefore, has no very distinct or peculiar characters of its own, it being a mixture of waters derived from various sources.

The water is conveyed by means of a long canal, known as the "New River." As it flows to London, it creeps slowly along, and this, as already explained, is one of the circumstances favouring the development of the lower forms of animal and vegetable life.

Other sources of impurity are to be found from the fact, that the New River, along much of its course, is accessible to the public, who use it as a resort for bathing in summer, and at all times as a receptacle for refuse animal and vegetable matter.

The quantity of *Oscillatoreæ* and *Diatomaceæ* seen floating on the tranquil surface of this canal, during the summer months, is immense, and must certainly seriously affect the condition of its water.

East London Company.

The supply of this company is derived from the Lea; this river rises near Dunstable, and after passing through or near to the villages of Luton, Herpenden, and Hatfield, it is joined at Hertford by the small rivers Beane, Rib, and Maran, and below Ware by the Ash; from Ware it flows on to Hoddesden, Cheshunt, Waltham Abbey, Chingford Green, Higham Hill, Tottenham, Upper Clapton, Old Ford near Stratford, Bow, Bromley, and on to the Thames, which it reaches near Blackwall, forming the embrochure called the Blackwall Creek.

The *Beane* rises near Baldock, and passes through or near to Stevenage, Watton, and Sacomb, on its way to Hertford.

The *Rib* commences near Buckland, and passes near Buntingford, Great and Little Hormead, and Braughin.

The *Maran* has the villages of Codicote and Walwyn upon it.

The *Ash* rises beyond Bishops-Stortford, is navigable for barges, and is sometimes called the Lea and Stort Navigation Canal.

The villages and towns, with their populations on or near the Lea and its tributaries to Lea-bridge, are the following: Dunstable, 2,582; Luton, 7,748; Herpenden, 1,872; Hatfield, 3,646; Hertford, 12,158; Codicote, 906; Walwyn, 1,395; Baldock, 1,807; Stevenage, 1,725; Watton, 920; Sacomb, 325; Buckland, 435; Great and Little Hormead, 716; Braughin, 1,358; Ware, 4,653; Sawbridgeworth, 2,391; St. Margaret's, 92; Broxbourne, 2,386; Cheshunt, 5,402; Waltham Abbey, 4,177; Chingford Green, 971; Tottenham, 8,544.

United population, 69,112.

The populations of Buntingford and Hoddesden could not be ascertained.

Now, although it is probable that some of the towns above enumerated may not drain into the Lea, yet some of them certainly do; it is, therefore, evident that the water of that river is contaminated with sewage.

It is at Old Ford near Stratford, and below Lea-bridge that the works of the East London Water Company are situated.

The nature of Blackwall Creek is pretty generally known; the waters of the Lea in it are filthy and impure, the bed of the river at low water is small and insignificant; so much so that barges have to wait for the tide, and into it is poured the refuse of the numerous manufactories situated on the banks of the Creek.

The tide of the Thames affects the Lea beyond Old Ford, that is some two miles above the point at which the East London Water Company has its works. It does not reach Lea-bridge, being intercepted by locks which serve the double purpose of keeping the Thames tidal waters out, and of damming in those of the Lea, which otherwise would be lost in the Thames.

Moreover the Lea is a barge river, and its waters are constantly stirred up in opposite directions by the passing and repassing of the barges, which go up the stream as far as Hertford.

It is to be observed, further, that the Lea runs through

a low and marshy country, liable to become flooded in rainy seasons, and intersected with dykes and ditches, the impure washings out of which it constantly receives: the water of the Lea is, therefore, to a great extent, surface drainage water, in my opinion a very objectionable kind of water.

The East London Water Company has a communication, by means of a small open canal, with the Lea just below the bridge, but still not out of the influence of the barge traffic; through this it professes to receive all the supply which it requires: this may be so, yet the connexion of the works by flood gates with the Lea at Old Ford looks suspicious, and should be closely examined. If it does take any part of its supply from Old Ford, then undoubtedly the water is contaminated by the impurities of Blackwall Creek and Stratford, and is for the most part Thames water itself.

Hampstead Company.

The Hampstead Company derives its supply principally from several large ponds situated near to Hampstead Heath; these are filled, partly by surface drainage and partly by springs; some of the ponds being evidently contaminated with sewage.

Of these ponds some are the property, or, at all events, are under the control, of the company, and these are in a tolerably clean condition; others, from which also part of the water used proceeds, have a different proprietorship, and are in an exceedingly unclean state, thus there is a large pond in the "Vale of Health," full of weeds, swarming with animal life, the receptacle of some dead animals, and into which no inconsiderable amount of sewage passes; the contents of this pond, so far as could be ascertained, drain into the company's ponds. Surely the "Vale of Health," if it really merit its pleasant name, would be still more healthful if this baneful pond were filled in or removed as it ought to be; there is also a large pond belonging to the Lord of the Manor, full of weeds, *Algæ*, *Entomostracæ* and *Infusoria*, and the surplus water of which also passes into the other ponds; again there are two or three ponds, in the domain of the Earl of Mansfield, in a weedy condition,

and from which the water undoubtedly drains into the ponds of the Hampstead Water Company.

But, it must be mentioned, that part of the supply of the Hampstead Company is derived from two Artesian wells, one near the Heath, and the other, I believe, at Somers Town; with the capabilities of these wells I am not fully acquainted.

Now the water of several of the Hampstead ponds has been subjected to careful microscopic examination, and it has been found to contain precisely the same forms of animal life which were encountered in the water of the Company as supplied to the public, and some of which forms are represented in Plate III, fig. 2. Regarding, then, all the facts in this case, it is impossible to say that the water distributed to the public by this Company is in the condition which a scrupulous regard to health and safety demands.

Kent Company.

This Company is supplied by the Ravensbourne, a little stream which rises near Bromley in Kent, and after a short course, in which it passes through Rushey Green and Lewisham, joins the Thames at Deptford, forming the Deptford Creek, which is even in a worse condition than the Blackwall Creek; below Lewisham a large branch, which comes from St. Mary's Cray, unites with the Ravensbourne.

The Ravensbourne, like the Lea, receives the washings out of dykes and ditches, and, in many parts of its course, is exposed to the public, and therefore to many sources of impurity; above Deptford, and close to the water-works, I noticed two or three dead dogs and cats.

At Deptford, and just below a large mill, there are tide-gates which keep out the filth of the creek, it is to be hoped effectually and entirely; notwithstanding, however, this very necessary and proper precaution, the River Ravensbourne is to be objected to as a source of supply, on account of its smallness, its exposure to the public, and the consequent deterioration of its water.

The above sketches of the sources of supply of these companies are brief and imperfect; a more careful and

extended examination would, I am satisfied, bring to light other facts in relation to them of equal importance and interest.

GENERAL REMARKS.

It has now been shown :—

1st. That Thames water within the range of the river, from which the several Metropolitan Water-companies take their supplies, contains solid organic matter, both dead and living, in considerable quantities.

It has been stated, also, and the facts rest upon unquestionable authority, that this water holds in *solution* likewise *much fluid* organic matter, as well as certain gases, as the *sulphuretted, carburetted,* and *phosphuretted hydrogen* gases—the former in considerable, the latter in smaller, amount.

It is to be remembered, also, that the Thames water contains not merely the sewage of a city comprising upwards of two million inhabitants, but also the refuse of gas, chemical, and various other works.

Lastly, it holds in suspension an enormous quantity of earthy particles, constantly stirred up by the river traffic.

It has been shown,—

2d. That the water supplied to the public by the Metropolitan Companies contains organic matter, living and dead, also in large amount; and, according to my observations, the *living,* even in larger quantity than the Thames water itself.

This water likewise contains sewage, soluble organic matter, the gases previously referred to, and earthy particles.

It has been stated :—

3d. That the water of cisterns furnishes in general a greater amount of living vegetable and animal productions than the same water as supplied by each Company.

These results of the application of the microscope to the examination of water, are precisely such as reflection alone would teach one to look for.

Animal life is present in water only under circumstances in which a sufficient supply of organic matter is provided for its sustenance; the detection, therefore, of any form of

Infusoria implies the presence of the food necessary to support it. In Thames water we meet with the exact condition, as respects nourishment, requisite to sustain animalcular life on a large scale, viz. an abundance of organic matter, derived mainly from the sewage; and, as a necessary and wise result of this, the lower forms of animal life abound to an amazing extent in Thames water.

The *Infusoria* are to be regarded as scavengers; and their purpose in the animal economy is to remove, in the least objectionable and injurious manner possible, the dead and decomposing organic matters, which, if allowed to pass through the ordinary stages of decomposition, would give rise to the formation of certain offensive and deleterious gases.

The increase of the living contents of the water supplied by those Companies who make use of the Thames as their source of supply, is clearly traceable in many cases to the treatment it receives subsequent to its removal from the river. It is first conveyed into large tanks or reservoirs—that is, it is removed out of the influence of the ebb and flow of the tide, the very means on which the purity of rivers mainly depend. In these reservoirs it is retained for a given time in a quiescent state, exposed to sun, air, and light—circumstances in every way favorable to the rapid development of the animal and vegetable life peculiar to water.

It seems to me, therefore, preferable, if practicable, that, instead of being dammed up in reservoirs to breed and stagnate, the river water, impure as it is, should pass directly to the dwellings of the inhabitants; the only useful purpose effected by its detention would appear to be, the separation of the heavier and earthy particles of the water, its least injurious impurity.

Lastly, the augmentation in the quantity of organic matter, generally found in cistern water, evidently arises mainly from the same causes which determined its increase in the water of reservoirs—namely, its motionless condition, and general exposure to light, air, and the sun.

If the contrivances of reservoirs and cisterns, as at present

designed and managed, had been purposely adopted, with the express view of effecting the deterioration of the water, it is difficult to imagine more efficient appliances for the attainment of this object; motion, which is ensured, naturally, by means of tides, wind, and rain, is, so to speak, the very *life* of water. In reservoirs and cisterns we deprive it of this motion, and, consequently, of its life; it then, like other lifeless things, becomes stagnant and corrupt.

The Purer Waters.

But it may be remarked, in objection to certain of the preceding details, that all water contains dead and living organic matter; this observation is true only to a limited extent, and admits of a satisfactory answer.

The purer waters contain scarcely a trace of organic matter. Thus rain water, examined immediately after it falls, does not contain *Infusoria*, or other forms of animal or vegetable life; in some cases, indeed, the ova of certain very minute animalcules may possibly be detected in it, as well as the sporules of fungi; these last, it is well known, being commonly disseminated through the medium of the atmosphere; in certain parts of the world, also, the phenomenon of the descent of animal and vegetable productions in showers has been from time to time observed, but such occurrences are rare and unusual.

In recently distilled water organic productions are not to be detected; after the lapse of some considerable time, filaments of fungi do frequently appear in it, and at a still later period, the most minute forms of animal life, the monads, become visible; but for the presence of these in carefully distilled water, excluded from the air, the space of many months is required.

The appearance of fungi in distilled water is one proof of their conveyance by the air, while the general and, for the most part, complete absence of animal life, gives support to the remarks previously made respecting the food of *Infusoria*. In distilled water there is little or no organic matter or pabulum, and this is one of the chief reasons of its freedom from animalcules.

Again, the waters of springs and of our deeper wells are all but absolutely free from organic matter, dead or living; it is indeed true, as shown by Dr. Hassall, of Richmond, that the water of the shallower wells is often contaminated to a large extent with living animalcules and dead organic matter, and the explanation of which circumstance is to be found in the fact of the frequent juxta-position of wells, cesspools, and drains.

The purer river waters, as those which are not contaminated by admixture with sewage, &c., do not contain anything like the same amount of dead and living organic matter as Thames water, from the vicinity of London; nor are they, therefore, impregnated to the same extent with soluble and gaseous organic matter.

These are important distinctions, and are quite sufficient to explain why one water should be pure and wholesome, and another impure and deleterious, neither being entirely free from organic matter.

Impure water in what way prejudicial to Health.

It now remains to explain in what way the presence of organic matter, dead and living, in large quantity becomes injurious to the public health. At the same time, however, it must be distinctly borne in mind, that the impurity of *Thames* water is the result, not alone of its *organic* matter, but is due in part to other contaminating influences.

The contemplation of the extraordinary forms and remarkable structure of the majority of the living creatures found in impure water, as well as the large size of many, would create, it might be supposed, in the minds of most people, an insuperable repugnance to use as a beverage any fluid suspected even to contain them. When, also, the marvellous powers of reproduction possessed by some, and the countless numbers of others, are remembered, together with the mystery which hangs over many of them as respects their capability of attacking the human frame (I allude more particularly to the tribe of *Fungi*), grave doubts and misgivings might fairly be entertained as to the propriety of drinking such water, and a sufficient case would be

made out to justify the adoption of every precautionary measure.

But there are reasons still stronger why water containing organic matter, living and dead, in large quantities, should be prejudicial to health: this matter is perpetually undergoing decomposition, and the elements of which the several vegetable and animal tissues are composed become rearranged, giving rise to the formation of the gases already referred to, and which are so pre-eminently injurious to life.

That these gases do not exist in small quantities, at least, in Thames water, is shown by the fact, before mentioned, of the constant evolution from the water of bubbles, composed of one or more of them.

One of the most deleterious of these gases, sulphuretted hydrogen, exists, as has already been stated, in very large quantities in sewer water; and this water, it must be remembered, all finds its way ultimately into the Thames, which therefore must contain the gas in question to, at least, an equal extent, although doubtless in a more diluted form.

That Thames water does very constantly contain this gas in considerable and appreciable quantity, may be shown by positive experiment.

Acetate of lead, added to three separate portions of this water, obtained on different days, and at distinct parts of the river within the reach of the bridges, gave abundant and satisfactory evidence of the presence of sulphuretted hydrogen, indicated by the subsidence of a brownish sediment, a sulphuret of lead.

Now, in order to avoid all possibility of deception or fallacy, these experiments were repeated several times, and every precaution taken to ensure certainty of result. Thus, Thames water was carefully filtered through bibulous paper until it became colourless; tested afterwards for the gas, a precipitate of the same tint as in the former cases fell to the bottom of the glass; it is evident, therefore, that no part of this tint could have proceeded from combination of the lead with any colouring matter contained in the water. Again, water known to be impregnated with sulphuretted

hydrogen, a stream of that gas having been passed through it, furnished a similar precipitate.

In testing Thames water for sulphuretted hydrogen with acetate of lead, the result is more evident, if at the same time we add a portion of lead to some pure water, not suspected to contain this gas: in the one case, the precipitate will be of a pure white colour; in the other, if the gas be present, it will be of a light brown or fawn colour.

Should the gas at any time not be detected by the proceeding indicated, which, however, has not happened as yet, in any case, to myself, preserve the sediment obtained from a wine bottle of Thames water in a stoppered phial, and, after a few days, again test, when it will, no doubt, be found.

The quantity of this gas present in sewer water, and its deadly nature, are shown by the following experiments:

1*st Experiment.*—A given quantity of Thames water, known to contain living *Infusoria,* was added to an equal quantity of sewer water; examined a few minutes afterwards, the animalcules were found to be either dead or deprived of locomotive power, and in a dying state.

2*d Experiment.*—A small fish, placed in a wine-glass of sewer water, immediately gave signs of distress; and, after struggling violently, floated on its side, and would have perished in a few seconds, had it not been removed and placed in fresh water.

3*d Experiment.*—A bird, placed in a glass bell-jar, into which the gas evolved by the sewer water was allowed to pass, after struggling a good deal, and showing other symptoms of the action of the gas, suddenly fell on its side, and although immediately removed into fresh air, was found to be dead.

These experiments were made originally with sewer-water obtained from the Friar-street sewer, they have since been repeated with six other sewer waters, and with the same results as respects the animalcules and the fish, but not the bird, this, although much distressed, yet survived the experiment.

There can, I think, be no doubt as to the injurious nature

of *dead* and *decomposing* animal matter; but next arises the question, is the *living* also hurtful to health?

The majority of living organisms, once received into the human stomach, doubtless speedily die, and are assimilated; it is undecided, however, whether this is the case with all, and this uncertainty attaches itself especially to the *Annelidæ,* or worms, and the *Fungi;* it is well known that several species of worms live in the human intestines, and even grow and multiply there; it is also a well-established fact, that the *Fungi* have the power of attacking and even proving fatal to many vegetable and the lower forms of animal life. I may here refer to certain experiments which I made some years since to test the aggressive and parasitic powers of *Fungi.*

Many fruits, as apples, pears, and peaches, and several vegetables, as the lettuce, vegetable marrow, potato haulm, &c., were inoculated with the sporules of *Fungi,* the result of this was that they all became speedily diseased, and in a few days many of them entirely disintegrated and destroyed. It is to be observed, that these experiments were made on healthy and growing fruits and vegetables; the former were still on the trees, and the latter rooted in the earth. In the softer fruits, as the peach and some kinds of apples and pears, the effects of the inoculation became visible in less than twenty-four hours; a dark spot, like that of mortification, first appearing, and this gradually extending in all directions until the fruit became completely disorganized.*

The vitality of the *Diatomaceæ,* so common in water, and the species of which are furnished with a skeleton of silex, is probably destroyed in passing through the system; the skeletons, however, resist digestion, and escape in an entire state; they, also, are not destroyed by boiling, even in strong nitric acid.

There is still another view, perhaps more important than any of the previous ones, to be taken of the presence of *Infusoria* in water, viz. that they are tests of its impurity and contamination by dead organic matter.

* For several papers on this subject, see Transactions of the Microscopical Society of London.

The use of waters containing living and dead organic matters cannot therefore, on several grounds, be too strongly condemned.

What are the symptoms, it may be asked, which arise in the human frame from the use of water largely contaminated with organic matter? This question it is not easy to answer in a satisfactory manner; it involves much knowledge and much personal observation and investigation. I would, however, at present reply to it as follows: We are not, in general, or except in times of epidemics, to look for any violent or suddenly injurious effects from the use of impure water; like the effects of vitiated air, those of bad water are, doubtless, in general, slow and insidious, but not the less important, or the less to be dreaded.

Smell of Water.

Now, it is to the presence of the *phosphuretted* and *sulphuretted hydrogen* gases that impure water mainly owes its smell; and the rapidity with which it acquires this smell, and the intenseness of the odour, may generally be taken as the test of the amount of the organic matter in a putrid state contained in that water. In proof of this, let a number of bottles be filled with different kinds of water, corked, and after the lapse of a few days, opened; it will then be found that the purest have little or no smell, whilst the more impure are fetid and offensive.

This test, applied to Thames water in general, confirms, in a most evident manner, the fact already referred to more than once, that this water contains largely organic matter; for, when treated as directed, it quickly acquires an odour in a high degree offensive and disgusting.

It has been frequently noticed, that Thames water shipped for voyages becomes, after a short time, putrid, but that it soon loses its fetor, and is sweet again. This has been related as a very curious circumstance; it is one, however, which admits of satisfactory explanation. The water is placed in tanks and tubs, which is the condition calculated to

ensure the speedy decomposition of the organic matter contained in it, but is unfavorable to its continued development, the water being withdrawn from the influence of air, and more particularly *light*. The organic matter, then, originally present, having undergone decomposition, and dissipated in the form of gas, and there being no renewal of it, the water becomes comparatively pure and sweet.

On a full consideration, therefore, of all the facts contained in the preceding pages, we cannot but arrive at the following conclusions:—

First, that the waters supplied by those Metropolitan Companies whose source is the Thames, are in a high degree impure, and therefore unfit for use, and detrimental to health: in this condemnation the waters of the Companies which supply the Surrey side of London, viz. the Vauxhall, Southwark, and Lambeth ought to stand first. The only Thames water supplied to the public in a condition *approaching* even purity is that (as it would appear) by the Chelsea Company. I would here call attention to the fact, that it was in the districts supplied by the Southwark and Lambeth Companies that the cholera, during its late visitation, was most prevalent and fatal; and no wonder, when it is considered that the inhabitants of these little favoured localities have not merely the worst water, but the worst, or, at all events, the least effective sewers, and the most vitiated atmosphere.

Second. That the waters supplied by the remaining companies, although purer than the former, are yet by no means in the condition required for comfort, health, or even safety.

As every opinion, however opposed to facts and reason, is certain to find its advocates, it would not be surprising that the statement should be made, that the various forms of life existing in the waters of the several metropolitan water-companies, exert a salutary influence. If so, the endeavour to find out a pure source of supply is, of necessity, a work of supererogation; and ditch-water, or that of stagnant ponds and pools, is preferable to that of the spring or pure river, as the three former contain these creatures in the

greatest abundance; and such persons would doubtless be prepared to argue in favour of these waters, teeming with life, that they serve the purposes of both meat and drink, and afford, when boiled, a nutritious soup, equal to that from the soup-kitchen of M. Soyer.

Remedial Considerations.

It has been shown, and the fact is established by incontrovertible evidence, that all those companies who take their water from the Thames draw it from a polluted source, and, so long as this river is employed as the outlet of all the sewage of so vast a city as London, so long must its water reek with abomination and filth. If, therefore, the water used by so many of the metropolitan companies be bad at its source, it can scarcely be otherwise than impure when delivered to the public.

In order, therefore, to obtain a supply of pure water, *the first thing necessary* will be to secure a source as free from contamination as possible.

With this view several projects have recently been discussed, and some are still before the public; the principal of these are the Wandle, the Watford, and the Henley-on-Thames plans, as well as the scheme of supplying London by means of a number of Artesian wells: on each of these plans we shall now proceed to offer a few observations.

The Wandle.

The river Wandle takes its source in certain springs at Waddon, near Croydon, and also in a large pond in the town of Croydon, and into which is poured the refuse of gas-works, of a tan-yard, and slaughter-house, as well as much of the sewage of the town.

There is also at Croydon a washing establishment on a gigantic scale, for the use, I believe, of the Chelsea pensioners, and the refuse waters of which find an outlet into the once famous trout stream—the Wandle.

At the inner spring at Waddon, the water is clear, and brilliant, entirely free from organic matter.

At the second spring or pond it is less so, owing to the weedy and unclean condition in which this is; and at the third pond much dead and living organic matter is met with; this pond being not merely filled with weeds and water-plants, but receiving a small stream from Croydon, which contains all the impurities before described as present in the Croydon pond, as well as probably the soap suds from the washing establishment.

The waters of the pond at Croydon tasted badly, smelled offensively, and were found, on microscopic examination, to contain—

1st. *Infusoria,* numerous; *Rotifer vulgaris, Paramecium caudatum, Bursaria vernalis, Oxytricha gibba? Trachelii, Euglena rostata.*

2d. *Confervеæ, Oscillatoria nigra,* in very great quantity.

3d. *Desmideæ, Closterium,* species of.

4th. *Diatomaceæ,* rather abundant, *Sphinctocystis librilis, Nitzschia elongata, Navicula inequalis, N. Phœnicenteron,* very abundant.

5th. Dead and decomposing organic matter.

The waters of this pond, therefore, were nearly in as bad a state as Thames water itself near the bridges. At Beddington, below Croydon, where the water appeared clear and bright, many of the same forms of animal and vegetable life were to be detected, and some of them were to be found as low down in the course of the stream even as Wandsworth, where the Wandle empties itself into the Thames.

The water of the inner spring at Wadden is then very pure, and remarkably free from organic matter; but that of the Wandle itself, owing mainly to its contamination by the contents of the pond at Croydon, is much less pure.

It was a matter of much surprise to me to find, in the heart of a flourishing and populous town like Croydon, such a plague spot as the pond in question, and its presence there is certainly a reflection upon the enterprise and spirit of the townsfolk. There is now a Board of Health at Croydon, and it is to be hoped that it will find means to effect the removal of this great nuisance.

The Watford Spring.

The Watford spring, of which we have all heard so much, is, in its present form, a well of considerable size and depth, from which the water rises to the surface in no very large quantity, as a very small wooden trough and ditch are sufficient to convey its overflowings to the contiguous river Colne.

The water of this spring is clear and bright, and, like that of most deep wells, is very free from organic matter.

The capabilities of this well to supply even a considerable section of London cannot be considered as yet to have been ascertained; and it appears to the writer that correct knowledge on this point can only be obtained by direct experiments, and these of a very costly description.

In favour of the water of the Colne, near to Watford, but little can be said; the microscope discovered in a wine bottle of it numerous *Infusoria* and *Diatomaceæ*, as well as much dead organic matter and grit.

As the river Colne was once the source of supply of one of the metropolitan water companies, the Grand Junction Company, and as it may be still in contemplation to make use of it, a brief sketch of its course may not be uninteresting.

The Colne rises near St. Albans, and passes through, or near to, Aldenham, Bushey, Watford, Rickmansworth, Denham, Uxbridge, Drayton, Colnbrook, and Staines, where it joins the Thames in three streams.

In this course, like other small rivers, it is exposed to the public, and it has upon it numerous mills and manufactories, of which there are several near Watford, which tend greatly to render its waters impure and deleterious. At Rickmansworth it is crossed by the Birmingham canal, another cause of contamination.

Artesian Wells.

Amongst the many projects which have been recently set on foot, with the view of securing an abundant supply of pure and wholesome water, there is one so peculiar and remarkable that I cannot avoid availing myself of the present opportunity

to offer a few remarks upon it. The proposal alluded to is that of procuring the required supply from a number of Artesian wells. Without entering at all into the purely scientific part of the matter, it appears to me that there is about it a degree of extravagance and opposition to nature.

It is in recent times only that engineering has arrived at such a state of perfection, as to render the operation of boring into the bowels of the earth, for so many hundred feet, a practical one; and yet Nature surely intended, from the very earliest period of the creation of the world, that the inhabitants of the earth should have a plentiful supply of that element, which is scarcely less necessary to life than the air itself. This abundant supply we obtain naturally from the pure and unpolluted rivers, which are to the earth's surface what blood and the circulatory system of vessels are to the animal economy. I regard, then, this merciless boring of the earth as a project involving not merely a vast outlay, but as one unnecessary and uncalled for.

We have levelled hills and filled-in valleys for our railways; we have explored the interior of the earth for its mineral wealth; and we have, likewise, to a small extent, tapped mother earth for water; but this grand and monster scheme of tapping I would protest against, not so much because it is wrong, but because it is expensive, uncertain, and unnecessary.

Henley-on-Thames.

We come now to consider the proposal of supplying London with water from Henley-on-Thames; it will, therefore, be proper to examine into the nature of the source of the Thames, to take notice of the towns upon its banks, and the population of those towns.

The Thames, properly so called, may be said to be formed by the union of the rivers Thame and Isis.

The *Thame* rises near Soulbury, in Buckinghamshire, passes through or near to Bierton, Quarrendon, Aylesbury, Thame, Holton, Stadhampton, and Wittenham, near to which place it joins the Isis, some five or six miles above Wallingford. The population of these towns and villages was, according to the last census, made in 1841, as follows:

Soulbury, 615; Bierton, 605; Quarrendon, 64; Aylesbury, 5429; Thame, 3060; Holton, 289; Stadhampton, 384; Little and Long Whittenham, 705.

United population, 11,151.

The *Isis* takes its origin in the confluence of several small streams, which issue from the Cotswold Hills, in Gloucestershire, as also from a copious spring, about three miles to the south-west of Cirencester, and which is known as "the Thames Head;" from this point, on its way to Oxford, it passes through or near to Sharncott, Cricklade, Lechlade, about twelve miles below which it is joined by several small streams, on which the towns and villages of Bampton, Winchcombe, Naunton, Rissington, Barrington, Burford, Minster-Lovell, Witney, Ducklington, Cockthorpe, and Standlake, are situated; hence it flows on to Oxford, near which it is augmented by the union of several other small streams, the river *Cherwell* amongst the number, and upon the banks of which also other towns are placed, as Shipton, Charlbury, Cossington, Deddington, North Aston, Woodstock, Marston, and Bicester. From Oxford it passes on to Abingdon, between which and Wallingford it receives the Thame, the confluence of the two forming the main stream of the Thames. The population of these places is as follows: Cricklade, 2128; Lechlade, 1000; Bampton, 2734; Winchcombe, 2613; Naunton, 523; Rissington, 1119; Barrington, 761; Burford, 1862; Minster-Lovell, 316; Witney, 5707; Ducklington, 541; Cockthorpe, 42; Standlake, 707; Shipton, 123; Charlbury, 2982; Cossington, 381; Deddington, 2025; North Aston, 289; Woodstock, 1412; Marston, 396; Bicester, 3022; Oxford, 23,834; Abingdon, 5530; Swindon, 2459; Shrivenham, 2353; Farringdon, 3593; Hanney, 1153; Marcham, 1009; Sutton Courtenay, 1378; Drayton, 521; Steventon, 948; Appleton, 496.

United population on the Isis, 73,957.

Ditto on the Cherwell, 7144.

The only villages and towns on the *Thames*, from the confluence of the Isis and Thame to Henley-on-Thames, are, Wallingford, 2780; Goring, 971; Whitchurch, 930; Pangborne, 804; Tidmash, 146; Reading, 18,937; and Wargrave, 1730.

United population, 26,298.

The principal streams which run into the Thames, below Wallingford and above Henley, are the Kennet, Loddon, and Blackwater.

The *Kennet* rises near Avebury, beyond Marlborough, and joins the Thames below Reading. It has upon its banks the villages and towns of Avebury, 751; East Kennet, 75; Marlborough, 3391; Mildenhall, 437; Hungerford, 2724; Newbury, 6379; Welford, 1099; East Woodhay, 1408; Newton, 1034; Enborne, 384; Thatcham, 4250; Woolhampton, 491; Padworth, 272; Ufton, 391; Shinfield, 1125.

United population, 24,211.

The *Loddon* and the *Blackwater* rise by several small streams in the county of Berkshire, not far from Basingstoke, and join the Thames by a common stream at Wargrave, about five miles above Henley; but few villages or towns of note lie in their course. Bramley, 428; Strathfieldsaye, 839; Hartley-Westpall, 351; Heckfield, 1325; Aldershot, 685; Frimley, 1535: Yately, 1997; Sandhurst, 562; Swallowfield, 1134; Wokingham, 3342; Twyford, 754.

United population, 12,952.

In order to form a correct estimate of the Henley project, we must next enumerate the towns upon the banks of the Thames, with their populations, below Henley, and between it and London, inclusive of the metropolis, as well as the villages and towns upon the several tributaries of the Thames, in its course from Henley to London.

The tributaries of the Thames below Henley, and between it and London, are the Colne, Wey, Mole, Yelding, Brent, and Wandle.

The course of the *Colne* has already been given; the villages and towns upon it, or connected with it by small streams, are, St. Albans, 2,904; Flamstead, 1,492; Colne, 544; Aldenham, 1,662; Bushey, 2,675; Watford, 5,989; Great Missenden, 2,225; Chesham, 5,593; Runer, 1,341; Rickmansworth, 5,026; Amersham, 3,645; Chalfont, St. Giles, 1,228; Chalfont, St. Peter, 1,483; Drayton, 802, Colnbrook, 1,050.

United population, 37,659.

The *Wey* rises near Alton in Hampshire, and passes through Farnham, Godalming, Guildford, Woking, and Weybridge, where it joins the Thames; in its course it receives two or three other small streams, which also have villages and towns near to them; Alton, 3,139; Farnham, 6,615; Fitcham, 373; Godalming, 4,328; Cranley, 1,357; Wonersh, 1,213; Wotton, 763; Shalford, 996; Worplesdon, 1,424; Woking, 2,483; Basingstoke, 4,066; Winchfield, 317; Odiham, 2,817; Perbright, 657; Chobham, 1,989.

United population, 32,537.

The *Mole* has its source in several small streams in the neighbourhood of the villages Rusper, Crawley, and Worth in Sussex, from which it proceeds into Surrey, passing between the towns of Reigate and Dorking, but nearest to the latter; from Dorking it flows into Leatherhead, Esher, and Moulsey, where it discharges its waters into the Thames; Capel, 989; Rusper, 564; Crawley, 449; Worth, 2,423; Ifield, 1,061; Horley, 1,583; Leigh, 495; Reigate, 4,584; Dorking, 5,638; Mickleham, 787; Leatherhead, 1,740; Esher, 1,261; Moulsey, 1,159.

United population, 22,733.

The *Yelding* is a small stream which rises near Harrow, and passes through or near to Ickenham, Yealding, Uxbridge, Cranford, Hounslow, and Isleworth, near which it discharges itself into the Thames: Harrow, 4,627; Ickenham, 396; Uxbridge, 3,219; Cranford, 370; Hounslow, 3,097.

United population, 11,709.

The *Brent* is also a very small brook, and has an equally short course with the Yelding; it rises near Hendon and passes through Kingsbury, Greenford, and Hanwell; from which it makes its way to Brentford, where it empties itself into the Thames. Hendon, 3,327; Kingsbury, 536; Greenford, 588; Hanwell, 1,469.

United population, 5,920.

The course of the last tributary of the Thames, the *Wandle*, has already been described; the principal villages and towns upon it are: Croydon, 16,712; Beddington, 1,453, and Mitcham, 4,532.

United population, 22,697.

In a short course of 10 miles, it, like other small streams,

has numerous, I believe as many as 98, mills and manufactories upon it.

It now only remains to ascertain the population of the towns on the Thames from Henley to London, inclusive of the metropolis and the suburbs: Henley, 3,622; Great Marlow, 4,480; Little Marlow, 927; Cookham, 3,676; Maidenhead, 3,340; Bray, 3,722; Windsor, 9,138; Eton, 3,609; Datchet, 922; Egham, 4,448; Staines, 2,487; Chertsey, 5,347; Weybridge, 1,064; Walton, 2,537; Hampton, 4,711; Hampton-Wick, 1,614; Kingston, 9,760; Twickenham, 5,203; Richmond, 7,760; Isleworth, 6,614; Kew, 923; Brentford, 2,174; Barnes, 1,461; Chiswick, 5,815; Hammersmith, 17,018; Kensington, 26,834; Fulham, 9,319; Wandsworth, 7,614; Putney, 4,684; London and suburbs, 1,873,676.

United population, 2,034,499.

These calculations may be arranged in a tabular form thus:

United Population of Towns on Thames and its Tributaries above Henley.

On Thame	11,151
Isis	66,763
Cherwell	7,144
Kennet	24,211
Loddon, Blackwater	12,952
Thames	26,298
Total	148,519

United Population of Towns on Thames and its Tributaries, from Henley to London, inclusive of the Metropolis and the Suburbs.

On Colne	37,659
Wey	32,537
Mole	22,733
Yelding	11,709
Brent	5,920
Wandle	22,697
Thames	2,034,499
Total	2,167,754

Total of population on Thames and its tributaries from the various sources as far as London, 2,323,470.

From a consideration of the above tables two things become evident; first, the extent of the contamination of Thames water near to London by sewage, and second, the fact that a considerable number of persons reside upon the Thames and its tributaries above Henley.

A closer examination of the tables shows, moreover, that a great portion of this population belongs to the towns of Oxford and Reading, with their adjacent villages; the sewage of these diverted, a matter of no great difficulty, nor one involving any very considerable outlay, then there would pass into the Thames above Henley a very small amount of sewage, and this too spread over a very large tract of country, and divided amongst several not inconsiderable tributary streams.

It is evident, therefore, that the Henley project must embrace at least the diversion of the sewage of the towns of Oxford and Reading.

This effected, and proper precautions taken to convey the water to its destination without further contamination, then, I believe, that it would be difficult to find a source of supply possessing so many advantages as the Thames at Henley; constancy and abundance of supply would be secured, both great desiderata, and water, unobjectionable in its chemical properties, and almost free from organic matter, obtained.

The value of a constant and abundant supply is shown by the effects of the dry weather of summer upon the capabilities of those companies who have recourse to limited sources, as the New River.

These capabilities are least in the hot weather of summer, that is just at the period when a full supply is most needed, when the cooling draught of water is sought for with avidity, and when a double quantity is needed for personal comfort and ablution.

The diminished quantity of water at the command of some of the companies in summer shows also to what an extent they are dependent upon rain and surface drainage water, for the spring and deep well, it is to be presumed,

scarcely yield a less volume of water in summer than in winter.

The Thames at Henley has also the following great advantage over any supply procured from small rivers; small rivers contain all the washings-out of dykes and ditches innumerable, the favorite resort of myriads of *Infusoria* and *Algæ;* they are, therefore, largely contaminated with organic matter, dead and living; now, large rivers become purified as they flow along; the *Infusoria* and *Algæ* transported from the stagnant ditch into the bed of the large flowing river, no longer find the conditions favorable to their rapid multiplication and growth; many of them become broken up and destroyed; decomposed and dissipated in the form of gas.

The superiority of Thames water at Henley over that at London scarcely requires to be proved microscopically: of two clear glass vessels, filled with the water obtained from each place, the one will be clear and bright, the other dirty and opaque; an examination by the microscope confirms, however, the superiority evident even to ordinary vision; for, although the water of the Thames at Henley does contain living productions, these are of a different kind, and are not present to anything like the same extent as in the water procured at London,—the organisms observed are principally *Diatomaceæ,* with but few *Infusoria,* the Thames *Paramecium* not being amongst the number. The sewage of Reading and Oxford diverted, and the banks, islands, and inlets of the river better preserved, then, I am sure, that the water would be still further improved.

I would here express my conviction, that no river water can be regarded as in a state sufficiently pure for use as a beverage, which has not previously undergone effective filtration.

I would observe that the tables given above are probably not accurate in every particular; it is not unlikely that some villages and towns have been included in them which do not really drain into the Thames or any of its tributaries, and that others which do so have been omitted; it must be remembered also that the calculations are founded upon a census nearly ten years old; it is believed, however, that they are substantially correct, and that they may be relied upon for all practical purposes.

Reservoirs.

The second step requisite, if practicable, will be, the entire abolition, or at least the material modification, of the system of reservoirs, and this principally for the reason already assigned—viz., that they greatly encourage the development of the lower forms of organic life.

I have been at the trouble of examining several reservoirs and ornamental waters, and I have always found them to contain living animal and vegetable productions in great quantities.

Reservoirs have three uses: when placed in elevated positions they serve to distribute the water to the district around to an equal level with that of the water contained in them; this is one use: a second is, that they hold a reserve quantity of water, to be used as occasion may require: but the third, and chief use, is that of allowing the heavier earthy and organic particles contained in the water, as poured into the reservoir, to subside: but connected with this use there is an evil of great magnitude; this organic matter in the reservoir goes on increasing from day to day, until at length there is such an accumulation of dead and decomposing substances as to affect the whole mass of water contained in the reservoir, and to cause it to leave it in a worse and more highly contaminated condition than that in which it entered it.

In corroboration of this effect of reservoirs, I would refer to the observations already made upon the state of the Cheshunt reservoirs belonging to the New River Company.

If it be necessary to clean cisterns frequently, it is equally so that some means should be taken to cleanse and purify the reservoirs, and that the organic and other impurities should not be allowed to go on accumulating in them from week to week, month to month, and in some cases from year to year.

Supposing, however, the abolition of open reservoirs to be impracticable, I am yet of opinion that their present condition might be very materially improved by attention to a few essential particulars. Thus reservoirs should be so con-

structed as to present the smallest possible surface to the action of air and light; they should be deep, with perpendicular, and not sloping sides, and they should be regularly and periodically cleansed; but above all, the water supplying the reservoir should be of the purest description, free from dead or living organic matter, and uncontaminated with sewage: these points attended to, then, I believe, that water would not suffer any material deterioration by detention for a few days in a large and uncovered reservoir.

Cisterns.

In the third place, the cisterns themselves should be either dispensed with, or undergo a thorough reformation, for they are faulty in their construction, and the faults are aggravated by neglect and bad management.

Examined at almost any period of the year, the following, in most cases, will be found to be the condition of each cistern: the lid is off, and the water exposed to air and light; on its surface floats a dark and frothy-looking scum in patches; these, submitted to the microscope, are found to consist of a mingled mass of filaments of *Oscillatoriæ*, frustules of *Diatomaceæ*, and *Infusoriæ*; on the sides of the cistern, there is observed a slimy pellicle of a deep-brown colour, composed almost entirely of *Diatomaceæ*; lower down are seen the bright-green filaments of certain *Confervеæ*, *Cladophora glomerata*, *Vesiculifera*, &c.; while at the very bottom, a copious deposit of earthy and organic matter is met with; lastly, diffused throughout the water, there are encountered several living species of *Infusoria* and *Entomostraceæ*, some so large that they are plainly visible to the unassisted eye.

If, now, inquiries be made with a view to ascertain how often the cisterns are cleaned, perhaps the answer will be, in one case, every two months; in another, twice or even once, a-year; and in a third, not at all. In some few instances, they are rinsed out every week, or once a fortnight, but such cases are exceptional and rare.

Enough has now been adduced to justify the observation

made above, that the faults of construction of cisterns *are aggravated by neglect and bad management.*

In cooking, the necessity for extreme cleanliness is recognised; and why should not the same cleanliness be observed with respect to water? A cook cleans her saucepan every day; and a cistern, to be pure and wholesome, should be treated after the same manner, and should be thoroughly scoured out at least *twice* a week.

It has been stated that cisterns *are faulty in their construction,* and this we shall now proceed to render evident. In almost all cases the cistern is of a square form, and the tap inserted about two inches above the level of the bottom; this form of cistern and position of the tap, allow of the accumulation of much sedimentary and organic matter, which, whenever the water is renewed, is stirred up, rendering it turbid and thick; it is this which explains much of the difference observed in the condition of the water taken from the cistern at various times.

I would suggest, therefore, that cisterns, if used at all, be made with rounded bottoms, the discharge pipes issuing from the centre; the result of this arrangement would be, that as soon as the water had settled, all sediment would escape with the first quantity withdrawn, and there would be no subsequent accumulation until the next time the cistern was filled.

Moreover, cisterns should be kept constantly covered; the necessity for adopting this precaution will become apparent from the following experiment:—Of two cisterns supplied by the water of the Hampstead Company, the one was kept always covered, and the other exposed; the latter, after a time, was found to swarm with animals of large size, *Entomostraceæ,* while the former was comparatively free.

But there are other considerations connected with cisterns which require to be noticed, as the *material* of which they should be manufactured, their *situation* and *supply.*

Material.—Cisterns are now, for the most part, composed of lead, composition, or slate; it is known that many waters act, to their own deterioration, on lead, while the composition cisterns, being rough on the inner surface, afford effectual

shelter to *Infusoria* and their ova; of the three materials, slate is the best; but it would not be possible to have in this the rounded form recommended. I would, advise, therefore, that cisterns be made of glass, marble, or earthenware. The glass cisterns would have this great advantage, that the slightest impurity would at once become evident, and the necessity for cleanliness palpable to the sight; they should, of course, be made of equal width top and bottom, to prevent accident from frost. The chief recommendation of earthenware, especially the *salt-glazed* kind, would be its cheapness, which would render it particularly suitable for the dwellings of the poor.

Situation.—Nothing can be more inconvenient or absurd than the practice of placing cisterns in situations difficult of access, in many cases even the assistance of ladders being required to reach them; and this is one of the reasons why so little attention is paid in general to their condition; the cistern of a house should be as accessible as the kitchen, or any other part of a dwelling.

But the difficulty of access is not the only fault in the placing of cisterns; a very general position is immediately over the closet, from the window of which usually sulphuretted hydrogen and other gaseous emanations of an impure character continually escape, a portion of these the water in such proximity cannot fail to take up.

Another not uncommon position is in the area, near the dust-bin, where it is subject to nearly the same kind of contamination as over the closet.

That sulphuretted hydrogen does escape from privies in large quantity, is shown by the following experiments:

A solution of acetate of lead in water was placed in a shallow vessel within the influence of the emanations of a privy; after the lapse of four days, a precipitate of a dark and dirty colour, characteristic of the presence of the gas in question, was observed in the vessel.

A piece of paper, smeared with carbonate of lead, and placed in the window of the privy, also after a time showed symptoms of discoloration.

Now, although the gaseous emanations from a privy are

more considerable than from a closet, yet there can be no question but that they are considerable in the latter case, especially in the warm weather of summer, when decomposition proceeds with extreme rapidity, or when the closet is out of order, which is frequently the case.

That water will absorb sulphuretted hydrogen from the air also admits of demonstration by experiment:

Some pure water was placed under a bell-jar containing sulphuretted hydrogen: tested the following morning, it gave distinct evidences of the presence of the gas.

A second portion of water was placed in a privy, so that it might be within the influence of the exhalations which proceeded from it, and it, too, after having been there for four days, was found to have absorbed an appreciable quantity of sulphuretted hydrogen.

Now, the above are simple experiments; but they are practical and convincing, therefore important.

Supposing the abolition of cisterns to be impossible, which I do not think is the case, the proper position of the cistern intended for domestic purposes, is evidently in the washhouse or some other adjoining building, where it would be under cover, and where its temperature would be but little affected by the sun.

Supply.—Finally, the water should be *daily* turned on to the cisterns, instead of three times a week only, as at present, in most cases. The necessity of this is obvious; for it is well known that in summer water will become offensive in less than twenty-four hours.

The water being daily renewed, would be found to be somewhat brisk in place of flat, as is generally the case at present; the briskness of the water of wells, and the flatness of that of cisterns, is a matter of common observation; this difference is attributable mainly to temperature, and here again the position of cisterns is at fault: mounted high up, and exposed to the action of the sun, the water in the cistern becomes warm, and a portion of the carbonic acid, upon which this briskness mainly depends, is expelled, hence the flatness; in the well the sun's rays do not reach the water, which is always cold; that is, it is in the exact

chemical condition calculated to enable it to absorb and retain the largest quantity of carbonic acid, and hence we find the explanation of the briskness of water.

The action of boiling water completely expels most of the gases, particularly carbonic acid and sulphuretted hydrogen; hence cold boiled water is never so brisk as the same water previous to its being boiled.

Filtration.

Filtration is an operation which is carried on in nature on a large scale, and in a very effective manner; looking upon the surface of the earth, and reflecting upon what passes there, many instances of filtration present themselves to our notice; it is by filtration that the water which falls upon the earth in dew, showers of rain, or storms of hail or snow, makes its way into the soil which it vivifies; it is by filtration or percolation that this water passes from the soil into the cellular tissue of the plant, which it pervades, imparting to it freshness and vigour; it is by this operation that the water of the river, as it flows along, fertilizes the adjacent fields and pastures; the water of the pure well, or that which gushes from the spring is filtered water, and man, in his attempts at filtration, is but a poor imitator, either in kind or extent, of the ways of Providence.

The importance of filtration it is almost impossible to over estimate, and in it some may be disposed to think a remedy exists for all the evils complained of in connexion with water; this, as will be seen presently, is not the case, for, although it is undoubtedly a remedy for some of those evils it is not so for all.

The method of filtration, to be successful even to a limited extent, must be very different from that pursued by the metropolitan companies; for we have seen that the waters which they supply, after having undergone the process as conducted by them, still contain much solid organic matter, living, dead, and decomposing, and often of considerable size, as shown by the occasional presence in our cisterns of small fish, &c.

To be fully efficient the process of filtration must be

superior even to that adopted by the vendors of filters, for these patented filters, although they intercept the larger and grosser impurities, dead and living, as the larger *Entomostraceæ, Infusoria, Desmideæ,* and *Diatomaceæ,* do not retain, at least I have not yet found one which will do so, the sporules of *Fungi* or the smaller *Infusoria ;* as, for example, the more minute species of the genera *Microglena, Cryptoglena,* and *Euglena,* some of which are to be found in most waters containing animalcules; and if they do not arrest these, then of course they allow of the escape of all other solid matters, organic or otherwise, as the ova of animalcules, certain species of *Naviculæ,* &c., of an equal size with them.

Again, the filters in common use do not in general remove the fluid organic matter, the salts, the gases, as well as a host of other soluble impurities. It will be seen, however, hereafter, that some of them do arrest certain of the gases in part.

Such being the faulty condition of the majority of the methods of filtration hitherto adopted, I have made a few experiments with the view of ascertaining the capabilities of different filtering media.

Filters are either mechanical or chemical; many of the mechanical filters have no chemical properties, but all the chemical ones are, to a greater or less extent, mechanical in their operation.

I first directed my attention to the *mechanical* properties of different media for filtration, experimenting with the following substances: coarse and fine bibulous paper, wool, sand, vegetable charcoal, animal charcoal, loam, mild clay, strong clay, and with the following results; it is proper to observe that the water employed as a test was the green pond water, the colour of which proceeds, for the most part, from the presence of myriads of *Infusoria* of the genera *Microglena, Cryptoglena,* and especially *Euglena.*

The water passed through *fine* and *coarse bibulous paper* retained a very evident green tinge, deeper through the coarse than the fine paper, and examined through the microscope was found to swarm with *Infusoria.*

Through a layer of *wool,* of about the fourth of an inch

in thickness, the water came out quite green; the result was nearly the same when passed through a stratum of twice the thickness; filtered through a compact layer two inches deep, it still retained a greenish hue, and much opacity; examined with the microscope, the *Infusoria* were found to be abundantly present.

These trials are sufficient to show, that the mechanical powers of wool for filtration are not great; nevertheless, I believe that this material is well adapted for preliminary and coarser filtration, on account of its durable qualities, the ease with which it can be replaced, and the rapidity with which the water escapes from it.

I was induced to make trial of wool, in consequence of the very favorable manner in which it has been reported upon by several French Commissions. The substance of one of these Reports I propose to give on a future occasion, as well as the results of some further experiments on filtration through wool.

Filtered through *sand,* it also possessed an evident green colour, and contained multitudes of animalcules, some of large size.

Passed through three different *patent filters,* it also came out retaining some colour and opacity, as well as numerous *Infusoria.*

In testing the powers of a filter, it is necessary that the first quart of water which passes should be rejected, as much of this, in general, does not consist of the water last placed in the filter, but of that retained in the filtering media from the previous filtration.

After filtration through *vegetable charcoal* the water entirely lost its green hue, but possessed a certain degree of opacity, and examined with the microscope the smaller animalculæ were to be detected in great numbers.

Passed through *animal charcoal* the water came out bright and transparent, without colour or opacity, and no animalcules could be discovered in it.

Through *loam* the water was still perceptibly green, and contained the animalcules in great abundance.

Filtered through *mild* and *strong clay,* the water was

nearly as clear and bright as through the animal charcoal, without trace of *Infusoria.*

It is now to be observed that, in all cases in which the *Infusoria* passed the filter, they were found, on examination with the microscope, to be in a living condition.

In those cases in which they were entirely retained by the filter, the animalcules did not penetrate into its substance beyond the depth of an inch, or at most two inches.

It may be objected to these experiments, that the green water employed was not fair test-water, inasmuch as filters are not in general required to purify such water; this objection is more specious than real, all water contaminated by *Infusoria* contains some of the smaller kinds of animalcules, and the ova of all; these, therefore, are equally liable to pass the filter as those of the green pond water, and that they do so is shown by the results of the filtration of Thames water given hereafter.

From the results of these experiments we may safely draw the following conclusions: 1st, that paper, sand, and loam, are bad mechanical filters; 2d, that vegetable charcoal and Patent Filters in general are not perfect ones; 3d, that animal charcoal, mild and strong clay, are perfect as respects their power of mechanically retaining the solid matter, dead or living, found in every, even the worst, descriptions of water; 4th, that inasmuch as the animalcules pass some media in a living state, that these, including loam, do not exert any chemical effect upon living organic particles.

It is to be noticed, further, that the *worst* mechanical filters are in general the *quickest* filters, while the *best* are the *slowest* in their action, and that of the perfect filters the quickest is animal charcoal.

A microscopical examination of the several filtering media explains, in general, the results obtained; thus the integral particles of the worst filtering media are large in size, while those of the best are small.

I next endeavoured to ascertain some of the *chemical* properties of filters, limiting my observations to their powers of absorbing and removing from water sulphuretted hydrogen and carbonic acid.

Paper, sand, and wool, being purely mechanical in their action, it was not necessary to experiment with them.

Sewer water, holding in solution a large quantity of sulphuretted hydrogen and of organic matter, emitting an odour in a high degree offensive, was passed through the following substances:

Vegetable Charcoal.—From this it came out free from smell, and colourless, yet evidently somewhat opaque; tested for sulphuretted hydrogen, this gas was not found.

Animal Charcoal.—Through this the water escaped clear and brilliant, without the slightest opacity, and showing no traces, on the application of tests, of the presence of sulphuretted hydrogen.

Patent Filters.—Passed through these, the water retained a slight tint of colour and opacity only, but furnished evident traces of the presence of the gas in question.

Loam.—From this the water came out in scarcely so pure a condition as from the filters, and also contained sulphuretted hydrogen.

Mild and Strong Clays.—Through these the water passed as clear and transparent as through the charcoal, but yet was found to furnish distinct evidences of the presence of the gas.

The sewer water, tested for sulphuretted hydrogen before being passed through a filter, gave with lead a dark brown precipitate; while, after having been filtered through the patent filters, loam, and clay, the colour of the precipitate was of a light brown.

It is, therefore, evident that all the above filtering media are, to a greater or less extent, chemical; and that, while some of them absorb the whole of the sulphuretted hydrogen, others retain only a portion of it.

Most of the patent filters are made with a certain amount of charcoal, and hence their chemical properties.

Now, although the water employed in these experiments was sewer water, yet the same proportional effects would follow the use of any water containing sulphuretted hydrogen.

The next experiments were directed to the ascertaining of

the effects of chemical filtration on the carbonic acid present in water.

Water highly saturated with carbonic acid, was passed through animal and vegetable charcoal, loam, mild clay, and three patent filters.

After filtration through *animal* and *vegetable charcoal*, a trace only of carbonic acid was to be discovered.

The water filtered through *loam* and *mild clay* contained the gas abundantly; but yet in very much less quantity than previous to filtration.

After passing through the *patent filters*, the water gave distinct evidences of the presence of carbonic acid, but in less amount than in that from the loam and clay.

Now the quantity of carbonic acid contained in the water experimented with, probably much exceeded that present in many gallons of ordinary water, and yet a single pound of charcoal was sufficient to remove all but a trace of the gas, its absorbent powers not being destroyed.

From these observations and experiments, it would appear, all things considered, that the best substances for filtration are vegetable and animal charcoal, and clay, mixed with certain proportions of sand.

Further, filtration, to be completely successful, should not consist of one process, but of two or three consecutive operations.

The faults of the majority of methods of filtration at present in use, including many of the patented filters, are much to be regretted; because, I believe, that they are unnecessary and remediable, and that filters may be constructed, either on a small or large scale, which would accomplish all that could be demanded of them, and all that a practical application of their powers would require.

Now, although I have pointed out, as a matter of duty, the defects of many patented processes of filtration, it must not be understood that these filters are useless; there is no question but that they effect a great deal in the way of purification, and I consider that no well-regulated house ought to be without one, especially if it have the misfortune to depend for its supply upon the Thames.

Many of the impurities in Thames water filters will remove, as shown by the results of two microscopic examinations, the one before, the other after filtration, the filter employed being one of Lipscombe's.

Before Filtration.—The water was dirty and opaque, containing much dead organic matter and grit, as well as numerous *Infusoria*, especially the Thames *Paramecium*, *Diatomaceæ*, and filaments of *Fungi*.

It also furnished distinct evidences of the presence of sulphuretted hydrogen.

After Filtration.—It came out clear and bright, without visible sediment or discoloration; examined with the microscope, nearly all the dead organic matter and grit was found to have been removed, and comparatively but few living productions were present: three or four *Paramecia*, *Oxytricæ*, and minute *Naviculæ*, with fragments of filaments of *Fungi;* and numerous ova and monads of small size.

No sulphuretted hydrogen.

I would conclude these observations on filtration by observing, that as the process is one which requires considerable care for its proper performance, and as it cannot therefore be safely left in the hands of the public—a large portion of whom neither understands its importance, nor has in many cases the means of carrying it into effect—the onus of it belongs, as a matter of right and of policy, to those public companies or bodies who take upon themselves the responsibility, at more than an adequate premium, of supplying the public with an article fit and safe for general consumption.

Summary.

The indispensable conditions, therefore, for a proper supply of water to a populous city like London are—

An unpolluted source.
An unlimited supply.
Perpetual renewal.
Filtration.
The abolition or modification of reservoirs and cisterns.
Moderate cost.

Conclusion.

I have entered thus fully and earnestly into this inquiry, from an appreciation of the important bearings of the subject, both in a moral and sanitory point of view.

We have the emphatic language of Scripture, enjoining the duty of cleanliness; but how can a people obey this injunction, who have not the requisite means at their disposal—viz., an abundant supply of water?

If I were desired to give an illustration of the close connexion existing between dirt and crime, I would point to certain well-known localities of this vast metropolis. Give the unhappy dwellers in these places pure water, and in abundance, and you will not merely better their moral condition, but you will materially lessen the expenses connected with gaols and criminal administration. In proof of this latter statement, I would refer to the operation of the baths and wash-houses for the poor, in lessening crime in those districts in which they have as yet been established.

But the sanitory view of this question is second only to the former; it is the premature deaths from pestilential diseases, occurring in these fearful places—forsaken by cleanliness, decency, health, virtue, godliness, and all that makes life pleasant and valuable—that swell up, often to such a frightful extent, our "Tables of Mortality." Pour into these localities plenty of pure water, and the lives of thousands will be saved, and the most effectual means taken to guard against a return of that heavy scourge—Cholera—upon which I would now make one or two remarks.

Cholera.

From the additional insight obtained into the nature of cholera, during its recent visitation, the absolute necessity, the imperative duty, of providing for the public a purer and more abundant supply of water, have become palpable.

There is no theory, in respect to cholera, which can harmonize and reconcile all the facts which observation and experience have taught us, which does not admit that that disease

takes its origin in some specific cause—in some peculiar organic poison; or, what is still more probable, some form of animal or vegetable life, capable, when introduced into the animal economy, of effecting its destruction.

There is no other theory yet conceived, which can explain why all persons, under the most opposite conditions of health and life, should be almost equally the subjects of cholera; why it should attack the temperate and strong, as well as the intemperate and weak, terminating the lives of both in a few short hours.

Now there are but *two ways* by which the organic matters above referred to can enter the animal frame—viz., by air and water. There are many facts tending to render it probable that it is by the latter that they are introduced.

In the preceding pages, the word sewage has been frequently employed; of the nature of this most persons have some general notion, but it is probable that but few have fully realized to their own minds its actual and loathsome composition: the sewage of London consists then of the contents of the closets and urinaries; dirty and waste waters of various descriptions, the washings of our persons and clothes; the refuse of gas, chemical, and a host of other works and manufactories, some of which are of the most unclean and offensive description, as those of bone crushers, the makers of glue and catgut, soap boilers, tanners of leather, &c.; the gore and filth of the slaughter-house, the knackers' yard and the dissecting room; the purulent discharges, cataplasmata, and other rejecta of the sick of our hospitals. The picture is already horrid and disgusting enough without further portraiture; it is proper, however, that in a matter of so much importance, there should be no concealment, but that the truth, the whole truth, fearful and tremendous as it is, should be known and publicly declared.

Well, this mingled and manifold corruption, termed sewage, passes from the sewer into the Thames, and from the Thames it returns to the public.

Now, this is not a mere assertion, but an undoubted fact

admitting of demonstration; thus I have shown that various matters, animal and vegetable, connected with sewage, including some of those of the fæces, are at all times to be detected in Thames water; and further, that the same substances exist in the waters of several of the companies as supplied to the public; the chain of evidence is complete and conclusive; thus the muscular fibre of the meat, as well as the more indestructible parts of the vegetable tissues consumed, have been repeatedly traced from the closet to the sewer, from the sewer to the Thames, from this to the companies' reservoirs, and from these back again to the public.

It is thus beyond dispute that, according to the present system of London water supply, a portion of the inhabitants of the metropolis are made to consume, in some form or other, a portion of their own excrement, and, moreover, to pay for the privilege.

Shall this state of things be permitted to last? is it possible that a system so infamous can long prevail? in the name of decency so outraged, and the laws of health so violated, I trust not.

Surely the days of this system are already numbered, and the date of its duration brief; even wealth and monopoly must yield before facts so damning; the indignation of the public is aroused, the attention of the Government is directed to the subject, the Board of Health is now prosecuting its labours, and collecting together the facts connected with a subject of such vast magnitude and social importance; the issue of all this will be, it is most earnestly to be desired, in the establishment of a remedy, full and complete, adequate to meet the evils of the case and the dangers which closely attend upon them.

Of this I am sure, that any government who would break up the present system of London water supply, and would give its sanction to such measures as would ensure to the people an abundant supply of pure and wholesome water, would be entitled to lasting gratitude, and I am certain would receive it. I believe that for a boon of this nature, involving comfort, cleanliness, health, and often life, the

people at large would be infinitely more thankful than for any purely political measure.

One of the most important and distinguishing features of the present age is the attention now bestowed on all matters connected with the sanitory condition of the people; for an appreciation of the importance of inquiries of this nature, as well as for the direct encouragement given to them, the thanks of the community at large are eminently due to the present Ministry. To contribute in any degree to the improvement of the social, moral, or sanitory state of a people, must be a subject of rejoicing and congratulation alike to the Executive and the individual, and there are few nobler works to which man could devote the best energies of his life.

But to return from this brief, but not inappropriate digression, to the subject of these pages.

Were an inhabitant of some remote kingdom informed, that in a city the largest in the world, and inhabited by a people the wealthiest and the most distinguished for their skill in the mechanical arts, a system of water supply prevailed, by which the dwellers in that vast city were made to consume their own excrement and offal, he would, I am sure, with extreme difficulty be brought to credit the tale, and would imagine that an attempt was being made to impose upon his credulity; and could one wonder at the disinclination shown to believe a story of such painful and fearful reality; and do we not ourselves, with all the facts before us, find it difficult to give to them a full measure of belief?

I would now observe, that the facts connected with the actual condition of water are very far from exhausted, and that much still remains to be done, not only in the way of remedy but also in that of inquiry; the purely scientific part of the investigation requires further development, the condition of the shallow wells, and their contamination by cesspools, should be ascertained; the state of the water supply of our Public Buildings, Barracks, Hospitals, Shipping, &c. should be inquired into and reported upon. The efficient performance of this duty would not involve any considerable

expense, and it would bring to light facts of much importance.

In conclusion, I beg to express the obligations I am under to Mr. Wakley, M.P., for certain suggestions which that gentleman was kind enough to give me the benefit of at the outset of these inquiries, and which the strong practical sense and ability by which Mr. Wakley is so distinguished, eminently fitted him to make. Much of the matter contained in the preceding pages first appeared in the 'Lancet' some weeks since.

Many subjects connected with water, of a more purely scientific character, are adverted to in evidence given before the General Board of Health.

THE END.

C. AND J. ADLARD, PRINTERS,
BARTHOLOMEW CLOSE.

EXPLANATION OF THE PLATES.

The figures contained in these illustrations were all drawn with the assistance of the *Camera Lucida*, and are magnified as nearly as practicable to the same scale, the *Entomostraceæ* being magnified only 60 diameters and the rest 100 diameters.

PLATE I.

THAMES AT BRENTFORD.

Annelidæ.

Fig. 1. A species of worm or Annelid.

Infusoria.

2. Oxytricha gibba (?)
12. Oxytrica cicada.
6. Uvella virescens.

Diatomaceæ.

3. Sphinctocystis librilis.
4. Gomphonema acuminatum.
5. Gomphonema dichotomum.
10. Nitzschia elongata.
7. Exilaria Ulna.
8. Gyrosigma Hippocampa.
11. Navicula, species of.

Dead Organic Matter.

9. Scale of moth.
13. Grit—dead organic matter.
14. Fragment of decaying vegetable.

THAMES AT HUNGERFORD.

Infusoria.

1. Paramecium Chrysalis.
3. Vorticella nebulifera, young.
4. Monads.

Annelidæ.

2. A species of worm or annelid, the same as met with in sewer water.

Fungi.

5. Filaments of fungi.
7. Beaded sporangia.

Diatomaceæ.

8. Nitzchia elongata.
9. Gyrosigma Hippocampa.

Dead Organic Matter.

6. Ochreous substance, or altered muscular fibre.

THAMES AT BRENTFORD.

THAMES AT HUNGERFORD.

PLATE II.

SEWER WATER.

Annelidæ.

Fig. 1. A species of worm or Annelid.

Infusoria.

2. Oxytricha gibba?

Dead Organic Matter.

3. A cell of potato.
5. Ochreous substance, or altered muscular fibre.
4. Two cells of the potato, coloured by iodine.
7. Vessels of plants.
8. Fragment of husk of wheat (not well delineated).
10. Black carbonaceous matter, the same is seen scattered over the field.
9. Granule of starch, coloured by iodine, and probably derived from the potato.

GRAND JUNCTION COMPANY.

Annelidæ.

Fig. 1. A species of worm or Annelid.

Infusoria.

2. Paramecium Chrysalis.

Confervæ.

4. Filament of Conferva.

Desmideæ.

3. Closterium Ehrenbergii.
11. Scenedesmus quadricaudatus.

Diatomaceæ.

5. Asterionella formosa.
7. Encyonema prostratum, immediately beneath which is seen a group of frustules of Gomphonema cristatum adherent to a filament of Cladophora glomerata.
12. Fragilaria pectinalis.

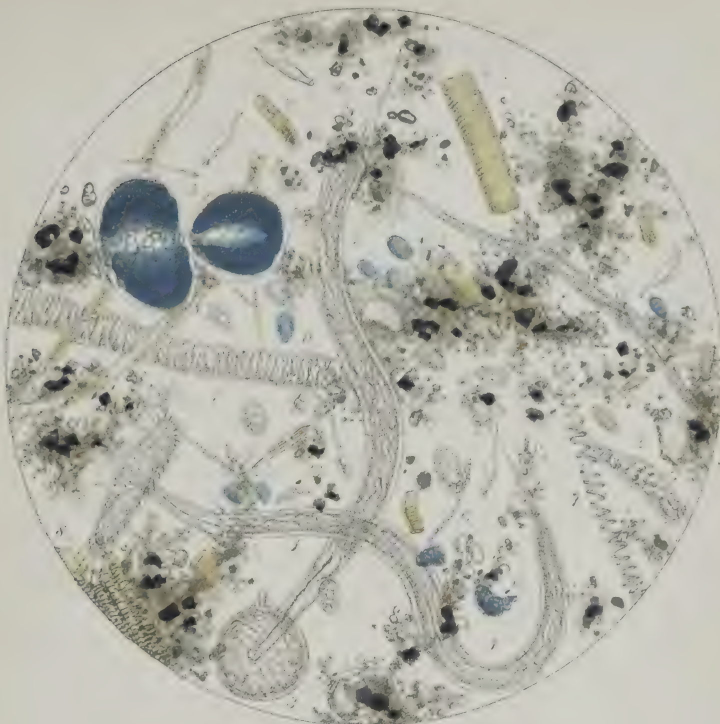
Fungi.

8. Filaments of two species of Torulæ.

Dead Organic Matter.

9. Hair of Mammal.
10. Spiral vessel of plant.

SEWER WATER.



GRAND JUNCTION COMPANY.

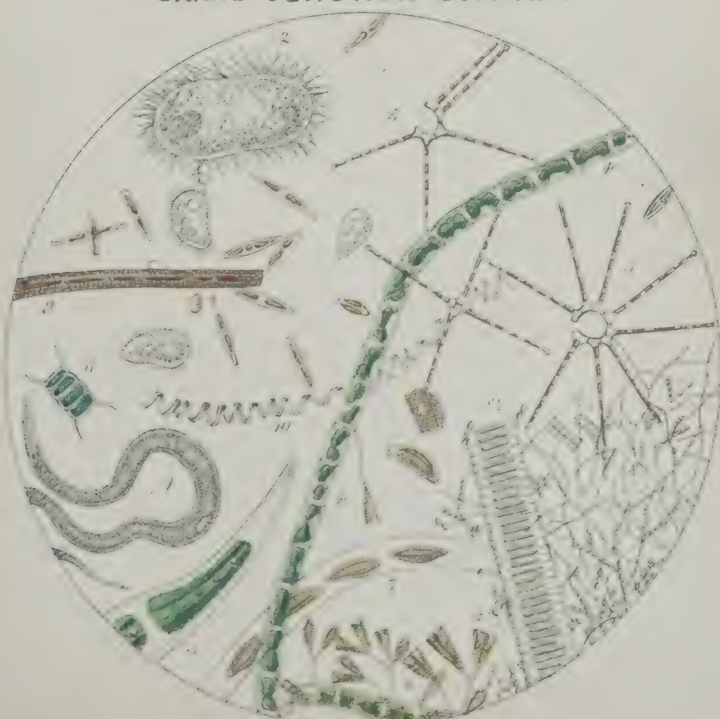


PLATE III.

WEST MIDDLESEX COMPANY.

Entomostraceæ.

Fig. 1. Cyclops quadricornis.
2. Lynceus longirostris.

Infusoria.

3. Paramecium Chrysalis.
4. Uvella virescens.
7. Peridinium furca (?).

Diatomaceæ.

5. Meloseira arenosa.
6. Asterionella formosa.
9. Exilaria Ulna.
10. Diatoma, species of.

Dead Organic Matter.

8. Earthy matter, &c.

CISTERN WATER.

Entomostraceæ.

1. Daphnia quadrangula, or water flea.
2. Cyclops quadricornis.
3. Lynceus sphæricus.
7. Amomyne fauna.
8. Amomyne satyra.

Infusoria.

4. Floscularia, species of.
5. Aneurea foliacea.
6. Brachionus, species of.

WEST MIDDLESEX COMPANY.

CISTERN WATER.

PLATE IV.

CHELSEA COMPANY.

Entomostraceæ.

Fig. 1. Cyclops rubens.
2. Ova of same.
6. A species of Nauplius.

Iufusoria.

3. Ova cases of some species of Infusoria.
4. Paramecium Chrysalis.
5. Actinophrys difformis.
8. Vorticella nebulifera, with circle of cilia drawn in

Dead Organic Matter.

7. Fragment of straw.

SOUTHWARK COMPANY.

Infusoria.

Fig. 1. Actinophrys difformis.
2. Paramecium Chrysalis.
3. Rotifer vulgaris.
4. Uvella, upon dichotomously branched stem.
6. Ova cases of Infusoria.

Diatomaceæ.

5. Gyrosigma Hippocampa.

Dead Organic Matter.

7. Hair of Mammal.
Much grit and organic matter scattered over the field.

CHELSEA COMPANY.

SOUTHWARK COMPANY.

PLATE V.

LAMBETH COMPANY.

Entomostraceæ.

Fig. 1. Cyclops quadricornis, with ova-bags attached.

Infusoria.

2. Paramecium Chrysalis.
3. Actinophrys difformis.
4. Oxytricha gibba.
7. Ova of some Infusoria.

Conferveæ.

5. Filaments of.

Diatomaceæ.

6. Nitzschia elongata.

Dead organic matter.

8. Hairs of Mammalia.
9. Hair of down of wheat.
Grit and organic matter in patches scattered over the field.

NEW RIVER COMPANY.

Entomostraceæ.

Fig. 1. Lynceus longirostris.
2. Vorticella nebulifera.
3. Bodo, species of.

Desmideæ.

4. Scenedesmus quadricaudatus.

Diatomaceæ.

5. Fragilaria pectinalis.
6. Gyrosigma Hippocampa.
7. Gomphonema truncatum.
8. Cocconema cymbiforme.
9. Gomphonema minutissimum.

Dead organic matter.

10. Decomposing vegetable matter, infested with monads.

Plate V.

LAMBETH COMPANY.

NEW RIVER COMPANY.

Preparing for Publication,

A Work, to be entitled,

HUMAN CRYSTALLOGRAPHY,

ILLUSTRATED WITH NOT LESS THAN THREE HUNDRED ORIGINAL AND COLOURED DRAWINGS.

BY

ARTHUR HILL HASSALL, M.B., F.L.S.

AUTHOR OF 'A HISTORY OF THE BRITISH FRESHWATER ALGÆ;' ALSO OF THE 'MICROSCOPIC ANATOMY OF THE HUMAN BODY IN HEALTH AND DISEASE.'

This work will contain Descriptions and Delineations of all the Crystalline Compounds met with in the several Fluids of the Human Body—the Blood, Milk, Urine, Bile, Semen, Mucus, Pus, &c.

That portion of the work devoted to the Description and Illustration of the Crystalline Formations occurring in the URINE will be rendered as copious and complete as possible.

The Human Crystallography may, therefore, be regarded, to some extent, as a work on Organic Chemistry.

The following sketches have already been prepared:—

Urea	2	Sugar	6
Urea-chlorides	7	Carbonates	3
Urea-phosphates	15	Oxalates	12
Uric acid	29	Oxalurates	2
Urates	8	Phosphates	22
Hippuric acid	2	Clorides	10
Alloxan	1	Nitratis	4
Cystine	2	Sulphates	20
Taurine	1	Miscellaneous	15
Cholesterine	4		
Benzoic acid	1	Total	166

The figures have all been drawn with the utmost care, by means of the *Camera Lucida*, and, as far as practicable, to the same scale.